COMPARISON OF THREE ALIGNING ARCHWIRES IN TERMS OF ALIGNMENT EFFICIENCY, STRESS DISTRIBUTION AND PAIN PERCEPTION – A PROSPECTIVE CLINICAL TRIAL

A Dissertation submitted to

THE TAMILNADU DR.M.G.R. MEDICAL UNIVERSITY

CHENNAI - 600032

In partial fulfilment for the degree of

MASTER OF DENTAL SURGERY

BRANCH – V

DEPARTMENT OF ORTHODONTICS AND DENTOFACIAL ORTHOPAEDICS

2016 – 2019

CERTIFICATE

This is to certify that the Dissertation entitled "**COMPARISON OF THREE ALIGNING ARCHWIRES IN TERMS OF ALIGNMENT EFFICIENCY, STRESS DISTRIBUTION AND PAIN PERCEPTION – A PROSPECTIVE CLINICAL TRIAL**" is a bonafide work done by **Dr.A.ABOOBACKER ALI,** Post Graduate student (2016-2019) in the Department of **ORTHODONTICS AND DENTOFACIAL ORTHOPEDICS**, Madha Dental College & Hospital, kundrathur, Chennai-69 under the direct guidance and supervision in partial fulfilment of regulation laid down by **The Tamil Nadu Dr.M.G.R Medical University**, Guindy, Chennai-32 for **Master of Dental Surgery**, Orthodontics and Dentofacial Orthopedics (Branch V) Degree Examination.

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ENDORSEMENT BY HEAD OF THE DEPARTMENT /HEAD OF THE INSTITUTION

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I, **Dr.A.ABOOBACKER ALI** hereby declare that this dissertation titled "**COMPARISON OF THREE ALIGNING ARCHWIRES IN TERMS OF ALIGNMENT EFFICIENCY, STRESS DISTRIBUTION AND PAIN PERCEPTION – A PROSPECTIVE CLINICAL TRIAL**" is a bonafide and genuine research work carried out in the Department of Orthodontics and Dentofacial Orthopedics, Madha Dental College and Hospital, Chennai -600069, under the conceptualization and guidance of my dissertation guide, **Professor Dr.M.C.SAINATH MDS.,MBA,PGDCR.** I have utilized the facilities provided in the Madha Dental College & Hospital for the study in partial fulfillment of the requirements for the degree of Master of Dental Surgery in the speciality of Orthodontics and Dentofacial Orthopaedics (Branch V) during the course period **2016-2019.**

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1.

2.

ACKNOWLEDGEMENT

I thank God Almighty, whose immense grace has been sufficient in all aspects in every circumstance encountered. He guided and helped me throughout my life in every endeavor and for that I am grateful.

At the outset, I would like to thank our founder of Madha group of academic institutions **Lion.Dr.S.PETER**, our managing director, **Mr.AJAY KUMAR,** and our vice chairperson **Mrs.MERCY FLORENCE,** Madha Dental College and Hospital for providing me with an opportunity to pursue post-graduation in the speciality of orthodontics and dentofacial orthopedics in their esteemed institution.

From the core of my heart I express my deep sense of gratitude and great honour to my respected guide, Professor **Dr.M.C.SAINATH MDS,MBA,PGDCR.,** Principal and Head of the department, Department of Orthodontics and Dentofacial Orthopedics, Madha Dental College & Hospital, chennai 600 069, for his conceptualisation, patience guidance, support and encouragement throughout the study.

I am grateful to **Dr.C.Karunanithi MDS.,** Professor, for his timely suggestions and support.

I am grateful to **Dr.R.Sathish MDS.,** Professor, for his timely suggestions and support.

I am grateful to **Dr.Shranya Dhevi MDS.,** Senior lecturer, for her timely suggestions and support.

I am grateful to **Dr.Preethi MDS.,** Senior lecturer, for her timely suggestions, untiring support and encouragement.

I would like to thank **Dr.Jhansi Ramani BDS.,** lecturer for her support.

I take this opportunity to thank **Prof.Dr.Sanjay.K.Nayak, Ph.D., D.Sc.,** Director General, CIPET[Central Institute of Plastic Engineering and Technology], Department of Chemicals & Petrochemicals, Ministry of Chemicals & Fertilizers, Government of India, Chennai for allowing me to utilize the lab facilities to complete my thesis.

I take the opportunity to thank **Dr.Nalini M.E, Ph.D.,** Scientist, for assisting me to carry out three point bending test.

I take the opportunity to thank **Mr.Jeevi ITI(Dip).**, Lab Technician in helping me to carry out three point bending test.

I thank the mathematical wizardry **Mr.Boopathy M.Sc, MBA.,** Department of Bio-Statistics, Senior Technical Officer**,** Indian council of Medical Research for carrying out the statistical analysis for the study.

I also thank my post-graduate colleagues **Dr.Viruthagiri, Dr.M.R.Vishnu, Dr.A.Adarsh, Dr.Saranya** and **Dr.Subashree** for supporting me in completing my thesis.

I sincerely express my gratitude from the core of my heart to all my patients who cooperated till the end of my study and written consents with full patience.

I would also extend my sincere thanks to my father **Mr.A.M.M.Anver Ali**, mother **Mrs.Seeni Ibrahimal**, brother **Mr.Sultan Thahir Ali** for giving me huge amount of moral support and courage during this venture.

I would like to thank my wife **Dr.Hashmath Sakeena Banu** for cooperating with me and bearing all the family responsibility throughout my entire course of study. Without her support it would have been really a very tough time for me. And special thanks to my daughter **A.Asma aaliya** being my source of happiness.

And I would like to thank my mother in law **Mrs.Tahira begum** for understanding my situation and giving a constant support to successfully complete my course

I would also like to thank my close friend **Dr.Charles Finny** for helping me in completing my thesis.

I would extend my sincere thanks to our hygienist and non-teaching staffs of the department for their assistance and service rendered during my post graduation course.

I would like to take immense pleasure to thank all those who have guided me throughout my post graduate curriculum.

ABSTRACT

AIM:

To clinically evaluate and compare the unraveling potential of the 0.014" Biostarter NiTi, 0.014" Heat activated Niti and 0.014" Superelastic Niti archwires during aligning and leveling stage of pre-adjusted edgewise appliance in crowded lower anterior teeth. To investigate and analyse the flexural stress distributed in these archwires and also to assess the pain perceived by the patients during the orthodontic treatment.

MATERIALS AND METHODS:

All the patients were bonded with 0.022x0.028" slot Ormco mini 2000 MBT prescription stainless steel metal brackets. Arch wires were placed in the lower arch in the same appointment. Arch wires were ligated using 3M elastomeric ligatures. Pre-treatment alginate impression and occlusal photographs were taken before the start of the treatment.

At the routine follow-up appointment at 4 weeks, the wire was removed and alginate impression was made and occlusal photograph was taken. This alginate impression was then cast with stone. The archwires were ligated and activated with elastomeric modules. The whole procedure was repeated again at 8^{th} and 12^{th} week. Readings were taken at 0-, 4-, 8-, and 12-weeks and measured using digital vernier caliper.

Assessments of pain/discomfort were made in the morning on a daily basis over the first 7-day period after bonding by means of a 10-point visual analog scale (VAS) of 10 cm length. All of the patients received a recording sheet with seven visual analog scales and were asked to mark the point on the line which they believed to best represent the maximum pain they experienced.

After the completion of 12 weeks of alignment, the wires were removed from patient's mouth and three point bending test were carried out with INSTRON 8874 machine to assess the flexural stress distribution.

RESULTS:

The results reveal that there is no statistical significance seen in the unraveling efficiency among the three archwire types in aligning the mandibular anterior irregularity. **(P = 0.64)**

There is a significant difference in the mean pain score among the three groups every day**(P=0.00)** with mean pain scores of Biostarter NiTi group causing the least discomfort to the patients followed by Heat activated NiTi and Superelastic NiTi.

Bio-starter NiTi arch wire exerted the least loading and unloading flexural stress among the three NiTi archwires but the mean stress value of Bio-starter NiTi archwire is not statistically

significant between the three archwires in both loading **(P=0.107)** and unloading situations **(P=0.070)**.

CONCLUSION:

There is no statistically significant difference in the unravelling efficiency between 0.014" Biostarter NiTi, 0.014" Heat activated NiTi and 0.014" Superelastic NiTi. But the patients receiving the Biostarter NiTi experienced the least pain/discomfort and also the flexural stress distributed in this archwire was the least among the three archwires, even though not statistically significant.

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INTRODUCTION

Orthodontic treatment without discomfort is an enigma to orthodontic practitioners. Many treatment modalities have been advocated and followed to reduce the discomfort and to accelerate the orthodontic tooth movement. Various orthodontic mechanotherapy and biomaterials have been introduced to alleviate the discomfort and to hasten the orthodontic tooth movement. Aligning and leveling forms the first stage of comprehensive orthodontic treatment in Pre-adjusted edgewise appliance therapy.

Ideally, the design of the archwire is to move the teeth with light continuous force, which may reduce patient's discomfort/ pain, damage to the supporting structures and root resorption.[1,2] The aligning archwires are used in fixed orthodontic appliance in the beginning of the treatment mainly to align the dental crowding and to correct the rotations.[3] Therefore the success of the orthodontic treatment may depend on the selection of the initial aligning archwires with less friction which hastens the alignment and to reduce the flexural stress exerted by the archwire which in turn reduces the pain/discomfort to the patient. As there are many archwires available, it is important to know which has the most efficient unraveling potential during the aligning stage of the treatment with minimal flexural stress and discomfort to the patient. Therefore it is important for the orthodontist to select the most

appropriate archwire with above cited qualities, to accomplish the desired tooth movement.

In early 1930s, gold alloys were the only orthodontic wires available. Later, austenitic stainless steel wires came which subsequently gained popularity over gold.[4] There after several contemporary alloys were developed, out of which nickel-titanium archwires gained huge popularity.

The use of NiTi archwires in Orthodontics was first described by **Andreasen and Hilleman** in 1975.[5] It is marketed as Nitinol by Unitek Corporation and was first invented in the early 1960's by William F. Buehler, a research metallurgist at the Naval Ordinance Laboratory in Silver springs, Maryland.[6] These nitinol wires had excellent elastic recovery property but they lacked superelasticty and shape memory because of the process of cold working of the alloy during manufacturing. Later on in 1985**, Burstone et al**[7] showed the high spring-back characteristic of Chinese Ni-Ti, followed by **Miura et al**[8] who introduced the superelastic Japanese Ni-Ti. In 1963, **Buehler et al**[9] observed the shape memory property of Ni-Ti alloy. In the 1990s, this feature was used in orthodontic archwires with the addition of copper to Ni-Ti alloy and was named as heat-activated Ni-Ti (HANT) or copper (Cu) Ni-Ti.[10] Since their development, improvements were made in their manufacturing and composition to improvise their properties. It has been suggested that

since superelastic NiTi archwires provide continuous light force to the teeth than other alloy archwires, it results in rapid tooth movement.

Light and continuous forces are needed to achieve physiologic tooth movement with minimal pathological effect to teeth and their surrounding structures.[1,2] Therefore optimal force must be used to produce enhanced tooth movement with the least discomfort/pain to the patient. The forces delivered by the archwire depend mainly on the physical properties and dimensions of the wire material. An ideal aligning archwire should have a good formability, stiffness, spring-back, biocompatibility, low friction etc.[4,11]

Thus friction plays a very important role as it can reduce the available force by almost 40%,[12] due to which optimal force may not be delivered on the tooth for alignment. Therefore, it is important to understand the impact of friction between the bracket and the wire so that the proper force level can be applied to obtain desirable tooth movement and optimum biologic tissue response.[12] In support to this claim various orthodontic archwires are available in market like Black Diamond Super-elastic NiTi archwire by Class One Orthodontics, Accel Low friction Thermal Nitaniumarchwire by Ortho Organisers, Black - Ti Super elastic Nitaniumarchwire by HenrySchein Orthodontics, etc.

Biostarter is a recent archwire introduced by the company Forestadent with the claim that the wire is extremely flexible and express the correct gentle forces on the patient's dentition and their uniquely smooth surface reduces the friction between archwire and bracket by up to 30%, thus decreasing the treatment time for unraveling the crowding.

Also the fear of pain is one of the important factor that may discourage patient from undergoing orthodontic treatment. **Lew**[13] had reported that about 30% of patients discontinue the treatment because of the pain experienced in the initial stages of orthodontic treatment. Moreover it is important to understand that the stress exerted by the archwires on the teeth is responsible for the discomfort/pain for the patient. Thus far no studies have proved that a particular archwire is best in terms of alignment efficiency, with minimal flexural stress distribution and discomfort to the patient. In an attempt to find out the best suitable archwire with these qualities, this study has been carried out to compare the above cited qualities of three different aligning archwires, namely the Biostarter (Low Friction) NiTi, Heat-activated NiTi and Superelastic NiTi.

AIM & OBJECTIVES

The aim and objectives of this study is to,

I. Clinically evaluate and compare the unraveling potential of the following archwires,

   (i) 0.014" Biostarter NiTi

   (ii) 0.014" Heat activated Niti

   (iii) 0.014" Superelastic Niti

   during aligning and leveling stage of pre-adjusted edgewise appliance in crowded lower anterior teeth by measuring the amount of tooth movement that occurs at 4-, 8-, and 12-week intervals.

II. Investigate and analyse the flexural stress distributed in these archwires.

III. Evaluate and compare the discomfort/pain perceived by the patients receiving these archwires during the orthodontic treatment.

REVIEW OF LITERATURE

ALIGNMENT EFFICIENCY OF ARCHWIRES

Kevin O'Brien et al EJO 1990[5] conducted a clinical trial to compare the super elastic properties of 0.016 inch superelastic Titanol and 0.016 inch conventional Nitinol archwires in alleviating mandibular anterior crowding over a period of 35 days in a sample of 20 patients in each group using standard edgewise brackets. The super-elastic properties of Titanol and Nitinol were also investigated by the means of a bending test. It was found that the Titanol possessed superelastic properties, which exerted a light force when compared to nitinol archwires. When tooth movement was analysed the mean movement per contact point for Titanol was 1.7 mm and for Nitinol 1.42 mm, which was not statistically significant. The results of the data analysis in suggesting that there was no significant difference between the amount of tooth movement between the two study groups.

Cobb NW et al COR 1998 [14] in a clinical trial with irregularity more than 5 mm, the rate of alignment was used to compare the alignment efficiency of 16 mil superelastic Ni-Ti and 17.5 mil triple-stranded stainless steel archwires and to determine whether implantation of ion into the Ni-Ti wire improved its performance. Both 0.018 and 0.022 inch slot edgewise appliances were used. Anterior irregularity was determined monthly using Little's

irregularity index until the score decreased below 2 mm, and the elastomeric ligatures were replaced at each appointment. Effective tooth movement occurred with each of the archwire types but there were no significant differences among wires, but the rate of alignment was significantly faster in the lower arch for subjects with the 22 slot appliance.

Nikolaos Pandis et al 2009 AJODO[15] conducted a single centre, single operator, double blinded study to compare the efficiency of copper-nickel-titanium (CuNiTi) and nickel-titanium (NiTi) archwires in resolving crowding of the anterior mandibular dentition. The patients were allocated randomly into 2 groups of 30 patients, each receiving a 0.016-inch CuNiTi and 0.016-inch NiTi wire. All the patients were bonded with In Ovation-R selfligating bracket with 0.022-inch slot and were followed monthly for a maximum of 6 months. Assessment of the alleviation of crowding involved only the mandibular anterior teeth. Measurements were made intra orally twice by the same clinician using a fine-tip digital caliber. The amount of crowding of the lower anterior dentition was assessed with irregularity index described by. No statistical difference was found between the two groups in alleviating the mandibular anterior crowding.

Emily Ong et al JO 2011[16] conducted a study with the aim of comparing the efficiency of orthodontic archwire sequences

produced by three manufacturers namely (i) 3M Unitek, 0.014 inch Nitinol, 0.017 x 0.017 inch heat activated Ni–Ti (ii) GAC international, 0.014 inch Sentalloy, 0.016 x 0.022 inch Bioforce and (iii) Ormco corporation, 0.014 inch Damon Copper Ni–Ti, 0.014 x 0.025 inch Damon Copper Ni–Ti in decrowding mandibular anteriors and also compared the discomfort caused these three archwire sequences All patients received 0.018 x 0.025 inch slot Victory Series^{TM} brackets. All three groups ended in the same working archwire, a 0.016 x 0.022 inch stainless steel archwire of Orthoform II archform (3M Unitek) to produce a common endpoint. It was found that there was no statistically significant difference found between the archwire sequences in the time taken to reach the working wire or reduction in irregularity index and also no differences were found in the overall discomfort score between the archwire sequences.

Satpal S. Sandhua et al 2012 AO[17] conducted a study which compared alignment efficiency of superelastic NiTi and multistranded stainless steel wires in the preadjusted edgewise appliance (PEA) & Begg's appliance under moderate to severe crowding conditions.0.0175 inch multistranded stainless steel and 0.016 superelastic NiTi archwires were used in the PEA with 0.022 x 0.028 inch slot Roth prescription twin brackets and in standard begg brackets. The study concluded that the performance of Superelastic NiTi was significantly better than multistranded

(coaxial) stainless steel wire in the Begg appliance. However, in Pre-adjusted edgewise appliance there was no significant difference.

Abdelrahman et al AO 2015[3] clinically evaluated the alignment efficiency of 0.014" superelastic NiTi, 0.014" thermoelastic NiTi, and 0.014" conventional NiTi in alleviating the mandibular anterior crowding. 74 patients requiring fixed orthodontic appliance therapy were randomly allocated into three different archwire groups. Patient's treatment plan which had both the extraction and non-extraction of the pre-molars were included in this study. All patients received 0.022 x 0.028 inch Roth prescription brackets. Measurements were taken every 2 weeks upto16 weeks. The change in tooth alignment was measured using vernier calliper in millimeters using Little's irregularity index to evaluate. The study demonstrated no significant difference found among the three NiTi archwire in terms of alignment efficiency.

CláudiaMaria de Castro Serafim, et al SWJ 2015[18] investigated and compared the time to correct mandibular anterior crowding using two arch wire sequences. One group with conventional NiTi and other with conventional NiTi and heat-activated NiTi wires. 22 boys and girls with moderate crowding were assigned randomly to one of two groups and followed up for five months when arch wires were changed. All patients were treated using a Roth fixed appliance, 022" inch slot bracket . The crowding was measured from

the study models, according to the irregularity index defined by Little . A digital calliper was held parallel to the occlusal plane for the measurements. Lower crowding was corrected in all of the cases in the group treated with the sequence that includes NiTi heat-activated arch wires, whereas about 30% of those treated with NiTi arch wires were not completely corrected. There was a significant difference in time to complete treatment between the groups. In the group treated with the sequence that included heat-activated wires, alignment and levelling of mandibular anterior teeth were completed earlier than in the group treated only with conventional NiTi arch wires.

Fırat Gok et al JWFO 2018[19] compared the arch width and depth changes and pain/discomfort with conventional and copper Ni-Ti archwires for mandibular arch alignment in 0.022 x 0.028 inch slot self ligating brackets. 32 patients were randomly divided into two groups with 16 patients in each group. Patients were selected based on characteristics such as moderate mandibular irregularity, orthodontic treatment with no extraction on the mandibular arch. The copper Ni-Ti group received 0.014-inch Cu-Ni-Ti at T0 (pretreatment) followed by 0.016-inch Cu-Ni-Ti at T1 (2-month interval), and the conventional Ni-Ti group received 0.014-inch Ni-Ti at T0 and 0.016-inch Ni-Ti at T1. Pre-treatment (T0) and post-treatment (4 months after initial treatment) characteristics were recorded from dental casts and included irregularity index,

intercanine width, interpremolar width, intermolar width, and canine depth, premolar depth, and molar depth. Each patient was provided with a specially designed visual analog scale (VAS) diary and requested to mark pain intensity in a 10-cm VAS at 4 hours, 24 hours, 3 days, 1 week, and 1 month, using the terms no pain (0) and the highest pain (100) perceived over the first month following the first archwire insertion (0.014-inch Cu-Ni-Ti and 0.014-inch Ni-Ti) and the second month after 0.016-inch Cu-Ni-Ti and 0.016-inch Ni-Ti archwire insertion. Pretreatment (T0) and posttreatment (T2) characteristics were recorded from dental casts, including irregularity index, intercanine width, interpremolar width, and intermolar width and canine depth, premolar depth, and molar depth. Alignment of six mandibular anterior teeth was evaluated by using Little's irregularity index from all study models. Intercanine widths were measured from the cusp tips of the canines, interpremolar widths from buccal cusp tips of the first premolars, and intermolar widths from the central fossa of the mandibular first molars. Arch depths were measured as the horizontal linear distance from the most anterior point of the central incisor to the line drawn between the tip of the canines, tip of the premolar buccal cusps, and the mesial contact point of the first molars. Measurements were made by using digital vernier calipers. The present study revealed that the copper Ni-Ti archwires were not more efficient than Ni-Ti archwires in leveling of the mandibular anterior teeth. The changes observed with arch dimensions (width as well as depth) were similar

with conventional and copper Ni-Ti archwires and the results were statistically insignificant in comparison.During the treatment period, the copper Ni-Ti and conventional Ni-Ti groups showed the same pattern of changes in the VAS scores between all observation periods, indicating that pain and discomfort are almost similar when conventional or copper Ni-Ti is used.

Burcu Aydına et al 2018 KJO[20] evaluate the alignment efficiency and intra-arch width dimensional changes NiTi and CuNiTi round archwires with increasing diameters applied in sequence to the mandibular arch over a period of 12 weeks. 66 patients were divided into the NiTi and CuNiTi group. Roth prescription brackets with 0.018- inch slot were used in both groups. The eligibility criteria were anterior mandibular crowding of minimum 6 mm according to Little's Irregularity Index, without therapeutic extraction of premolars. Both the groups received 0.014 inch arch wire immediately after bonding. In the next appointment which was scheduled 6 weeks latter, both groups received 0.016 inch archwire and continued for 6 weeks. The study was terminated after 12 weeks. No significant difference was witnessed between NiTi and CuNiTi according to little's irregularity index. The length of the arch-perimeter between the canines and first molars were significantly more in the CuNiTi group than in the NiTi group. A statistically significant three-way interaction was observed between the groups in terms of the inter-first premolar width . The increase

in inter-1st premolar width for the 0.014 inch NiTi archwire in the sixth week was more significant than that in 2nd and 4th weeks. For the 0.016-in NiTi archwire, the increases in arch width in the 4th and 6th weeks were similar and significantly more evident than those in the second week. The inter-dental width obtained at the end of the 4th and 6th weeks with the 0.014-in CuNiTi archwire was statistically significant than that obtained at the end of the 2nd week. For the 0.016-in CuNiTi archwire, the increase obtained at the end of the second, fourth, and sixth weeks was not statistically significant. As the study progressed, an increase in arch width was obtained for both types of archwires.

Majid Mahmoudzadeh[21] et al 2018 CEO conducted a study in which two initial archwires, 0.014"Superelastic A – NiTi(Active Austenitic NiTi) and 0.016" Heat activated NiTi were used to compare the efficiency in aligning the mandibular anterior crowding and the pain perceived by the patients. The study consisted the sample size of 59 patients whose treatment plan included the non- extraction of the pre-molars and the Little's irregularity index score more than 2 were only included. MBT prescription brackets with 0.022- inch slot were used in this study. The entire study was for a period of 4 weeks. At the end of bonding session, the modified McGill Pain Questionnaire with Visual Analogue Scale (VAS) was given to all subjects and asked to fill it out until the next appointment (after 4 weeks). The

Questionnaire consisted of questions concerning the trigger of pain, description, location, duration, intensity, beginning, and medication. In addition, the patients were allowed to take only the 325 mg acetaminophen tablets if necessary (that does not interfere with orthodontic tooth movement), and if so, it should be mentioned in the appropriate section of the questionnaire The results of this study showed no significant difference between 0.014 A-NiTi and 0.016 HANT wires in amount of tooth alignment and the pain perception.

PAIN PERCEPTION

Peter Ngan[22] et al 1989 Ajodo compared the perception of discomfort by the patients undergoing orthodontic treatment before the insertion of either separator or initial archwire and after the placement at 4 hours, 24 hours, 7 days using Visual Analogue Scale. Group receiving the separator consisted of 65 patients and those receiving initial archwire consisted of 57 patients. Of the 57 patients, 13 had an upper and lower arch Begg fixed appliance fitted with 0.016-inch base arch wires. In the remaining 44 patients, 0.022-inch edgewise brackets were bonded to the upper and lower arches and all brackets fully engaged with an initial 0.0175-inch arch wire. Orthodontic separators were placed in the mesial and distal contacts of the first permanent molars in all four quadrants for a period of 7 days. The sample of patients were also divided into groups according to the sex and age(16 years and less & more than

16 years). The results showed significant increase in discomfort level after the placement of either separator or archwire at 4 and 24 hours but not at 7 days. No significant difference was found in the level of discomfort of patients more than 16 years compared with those 16 years and under. However an interaction between the age and time factors was found to be significant that the patients 16 years and less experienced more discomfort at 4 hours, whereas patients more than 16 years experienced more discomfort at 24 hours and 7 days. Also it was found placement of separators tends to increase the level of discomfort on posterior teeth ,whereas wire placement tends to increase the discomfort in anterior region.

Malcolm Jones and Clement Chan[23] 1992 Ajodo compared the prevalence, intensity, and duration of pain perceived by the patients receiving Superelastic NiTi and Multistranded stainless steel archwire using Visual Analogue scale, Questionnaires and an analgesic consumption record. All patients received 0.018 x 0.030 inch standard pre-adjusted bioprogressive brackets were used. Three methods were used to assess the patients initial pain response after extraction of a premolar tooth, placement of first initial archwire, and placement of a second initial archwire in the opposing dental arch.18 out of 43 subjects underwent extraction and were used as control group. 22 of the 43 patients had second archwire in the opposing arch .It was found that the prevalence, intensity and duration of pain after the insertion of two types of archwires were

similar and were greater than the pain due to extraction. The pain score was highest in the morning after the placement of the archwire and lasted for 5-6 days .The pain experienced after the insertion of 2nd archwire was similar to the of the first . Diurnal variation was seen with the of increase in pain in the night although this did not greatly affect the sleep. The pain response was found to be highly and consistently subjective, not related to the dental arch, crowding, sex.

Philipp A. Scheurer[24] et al EJO 1996 investigated the severity, location and duration of patient's pain following the placement of orthodontic appliances and to examine for interactions between age, sex, appliance type and the perception of pain using VAS scale and questionerries. Appliances inserted were complete fixed appliance in one arch (n=52), in both the arches(n= 98), 2 x 4 appliance in one arch (n=10). Out of 170 patients, 65 per cent reported pain after 4 h,95 per cent after 24 h. After 7 days, 25 per cent of the patients still reported discomfort. Patient's pain intensity scores were significantly higher for the anterior than the posterior teeth. On day 1, 16 % of the patients took analgesics and 18 % reported being awakened the first night. Comparing the 2 x 4 appliance, a full appliance in one arch and in both arches, no statistical differences were found for pain frequency, intensity, discomfort when biting and chewing and analgesic consumption. The pain intensity, drug consumption, pain during eating and the influence of discomfort on

daily life were all significantly greater in girls than in boys. Patients younger than thirteen years had pain significantly less frequently than the older patients. The pain intensity did not differ among the age groups.

Lucete et al 1998 JOO[25] compared and investigated the pain experienced by 128 patients after the placement of 0.014 Sentalloy Superelastic NiTi and 0.014 Nitinol Conventional Niti wire with edgewise fixed appliance using visual Analogue Scale for the first seven days with the recordings made every hour for 11 hours of the first day. Results showed the discomfort level increased continuously every hour after the placement of either Sentalloy or Nitinol as the first archwire with the peak in the first night, remaining high on the second day and decreasing thereafter to baseline level after seven days. During the first 10 hours the pain felt after the placement of a sentalloy was found to be less than that found with the Nitinol archwire, although a significant difference could be found at 4 hours only. A statistically significant difference between the upper and lower dental arches was observed during the first 11 hours, with the lower arch experiencing higher pain level with both Sentalloy and Nitinol.

Aslihan M. Ertan Erdinc and Banu Dincer[26] **EJO 2004** investigated the initial time at which pain occurs after the insertion of two aligning archwires of different dimenshion, pain level, the

regions affected within mouth, the level of self-medication, the effect of pain on daily life and the gender difference. The study consisted of 109 patients receiving either 0.014 or 0.016 inch NiTi archwire by random selection. Pre-adjusted edgewise appliance with 0.018 inch Roth prescription brackets were used. In 0.014 inch group the archwire was inserted in both arches in 42 patients and in maxilla for 14 patients. In 0.016 inch group the wire was inserted in both arches in 41 patients and in maxilla for 12 patients. Following insertion of the archwires , a questionnaire comprising a total of 49 questions was given to the patients to describe the pain. The results shows that in both the groups initial pain was perceived at 2 hours, peaked at 24 hours and declined by day 3. No significant differences were found in terms of gender, period of initial pain ,areas affected by pain within mouth and the effect of pain on daily living with the 0.014 inch and 0.016 inch NiTi archwires. But it was found that pain perceived at the anterior region was greater than the pain in posterior region. The most highly affected daily activity was observed at 6 hours with 57% in 0.014 inch groupand 50.5% in 0.016 inch group.55% patient consumed pain killers in 0.014 inch group and 32 % in 0.016 inch group.

Satpal Singh Sandhu1 and Jasleen Sandhu[27] JO 2013 conducted a study to investigate the pain associated with the 0.016 inch superelastic nickel–titanium and 0.0175 inch multistranded stainless steel archwires during the initial phase of orthodontic treatment

with 0.022 inch Roth prescription brackets using Visual Analogue Scale with only mandibular arch bonded till the completion of the study. Totally 168 patients were assessed for the eligibility and 72 were excluded. 96 patients were finally selected and were divided equally into two groups. In this clinical trial, orthodontic pain began 1 h after initial arch wire placement, reached a peak on the morning of day 1 (24 h), and gradually decreased thereafter. However, even after 14 days, the mean VAS score did not reach zero. At the completion of 14 days of study it was found that for overall pain, there was no statistically significant difference between the two wires. However, subjects with superelastic nickel–titanium archwires had a significantly higher pain at 12hours to 24 hours after the wire placement.

Marcio José da Silva Campos[28] et al 2013 DPJO conducted a study with the aim to assess the intensity of toothache and buccal mucosal pain in adults and children during the two initial phases of the orthodontic treatment. The intensity of tooth ache and buccal mucosal pain reported by 20 patients , 10 children and 10 adults was recorded with the aid of a Visual Analog Scale (VAS). Mini Standard Edgewise American Orthodontic brackets were used.

On the morning of the 7th day, a 0.014-in pre-formed NiTi archwire was totally inserted in the slots of all brackets and in the tubes, being then fixed with a 0.010-in steel ligature wire. The

assessment was done for 14 days, which is divided into two phases: Bonding phase from days 1-7 and initial archwire phase from days 8-14. During the entire study period, patients did not use any analgesics or anti-inflammatory drugs. Upon completion of the study there was no significant difference in pain intensity for adults and children. After bracket bonding, 50% of the children and 70% of the adults reported pain. 70% patients in both groups reported pain after initial archwire insertion. After initial archwire insertion the peaks of toothache intensity and prevalence occurred 24 h in children and 48 h in adults. In general, children reported pain less frequently than adults did, though with greater intensity.

Anand Ambekar[29] IOSR 2014 evaluated the discomfort/pain caused by three aligning archwires 0.018 NiTi, 0.018 Cu NiTi and 0.0175 multistranded stainless steel in 0.022 x 0.028 inch MBT prescription pre-adjusted edgewise brackets. Recordings were done at the interval of 1 hr, 5^{th} hr, 10^{th} hr,24^{th} hr, 2^{nd} day and 6^{th} day. Pain and discomfort index demonstrated that, the pain level at 1st hour and 5th hour was almost same with multistranded stainless steel, CuNiti and NiTi wires. There was no statistically significant difference found between them. But at 10th hour to 3rd day the pain levels were increased with multistranded stainless steel and NiTI wires. The pain levels were low with CuNiTi archwire. Statistically significant difference was found between CuNiTi and NiTi wire. There was no statistically significant difference was found between

multistranded stainless steel and CuNiTi archwires and Multistranded stainless steel and NiTi wires. From 4th day to 7 th day the pain levels were decreased progressively for all wires and there was no statistically significant difference was found between them .Overall pain associated with copper NiTi was less as compared to multistranded stainless steel and NiTi archwire.

Abdelrahman[30] et al AO 2015 clinically evaluated the pain intensity daily for the first 7-day period after bonding with 0.022 x 0.028 Mbt prescription brackets by using of visual analog scale and consumption of analgesics following placement of three different orthodontic aligning archwires namely, 0.014 inch superelastic NiTi, 0.014 inch thermoelastic NiTi and 0.014 inch Nitinol archwire. Patients were divided into three groups with the sample size of 25 in each group and they were matched according to age, gender, degree of crowding and type of treatment. Extraction ,if needed was done at least three weeks before bonding. Upon completion, it was found that no statistically significant differences were found in the pain intensity with the three aligning NiTi archwires. No significant differences in pain perception were found in terms of gender, age, lower arch crowding, and incisor irregularity. Intake of pain killers was minimum in the superelastic NiTi group.

Ama Johal[31] et al AO 2018 evaluated the intensity and duration of pain percieved in adults during the first 3 appoinments of fixed appliance treatment. A secondary objective was to assess the interconnection between pain experience and analgesic use. All patients received a bonded with pre-adjusted Edgewise fixed appliance 0.022 x 0.028-inch slot size in either the upper arch only or both arches. A prospective longitudinal study design was adopted. Fifty-eight adults undergoing fixed appliance treatment in five orthodontic practices recorded pain experience at four time points (4 hours, 24 hours, 3 days, and 7 days) following the initial bonding appointment (T0) and first (T1) and second (T2) routine follow-up adjustment appointments using a visual analogue scale. In addition, subjects recorded the dosage and frequency of analgesic use. The initial archwire following bracket placement was a 0.014-inch super-elastic nickel-titanium archwire, to be re-ligated at the first (T1) and replaced with 0.016-inch super-elastic nickel-titanium archwire at the second (T2) routine follow-up adjustment appointment, with each appointment being 6 weeks apart. Archwires were engaged using elastomeric ligatures only, avoiding full engagement at the bond-up appointment for notably displaced teeth. After placement of the orthodontic appliance (T0), subjects were asked to record their pain experience, using a visual analogue scale (VAS), at 4 hours, 1 day, and then each consecutive day for a total of 7 days and any analgesic use, in terms of the type of medication, dosage, and frequency. This was repeated after T1 and

T2 routine follow-up adjustment appointments. It was found that highest pain was experienced between 24 hours and 3 days after the appliance placement and in subsequent adjustments. The highest mean pain score arose at initial bonding followed by 2nd and 1st adjustments, with the difference between pain levels at these appointment intervals being statistically significant. They also found that the use of analgesics following each appointment mirrored pain experience. The present study could not identify gender or age as a predictor of pain experience.

FLEXURAL STRESS DISTRIBUTION

Júlio de A. Gurgel[32] et al Ajodo 2001 conducted a vitro study to compare the force-deflection behavior of 8 superelastic nickel-titanium orthodontic wires (0.017 × 0.025 in) under controlled moment and temperature. To simulate leveling a lateral incisor, brackets and first molar tubes without tip and angulation were used. The wires were ligated into stainless steel brackets attached to a plastic jig to simulate a mandibular arch. A testing machine (Instron) applied deflections of 0.2 to 2.0 mm at 35°C in the lateral incisor area. Forces on deactivation at a deflection of 1 mm were compared by analysis of variance. Significant differences in forces were observed among wires. All wires exhibited superelastic behavior, but in stratified loading levels.

Peter D. Wilkinson[33] et al Ajodo 2002 investigated the load-deflection characteristics of 7 different 0.016-in initial alignment archwires (Twistflex, NiTi, and 5 brands of heat-activated superelastic nickel-titanium [HASN]) with modified bending tests simulating a number of conditions encountered clinically. Load-deflection tests were carried out on the wires with 5 different model designs, and data from selected points on the unloading phase of the generated graphs were statistically analyzed. Three-point bending with brass jig, Partial acrylic block model with 4 Mini-Diamond Brackets, Partial acrylic block model with 4 Twin-Lock self-ligating brackets, Full acrylic arch form with maxillary arch Mini-Diamond brackets, Full acrylic arch form with maxillary arch Twin-Lock brackets were the five different models for the measurement. Wire deflection was carried out at 3 temperatures (22.0°C, 35.5°C, and 44.0°C) and to 4 deflection distances (1 mm, 2 mm, 3 mm, and 4 mm). Rankings were derived according to statistically significant differences in each test situation. The effects of model, wire, and temperature variation were all statistically significant. Twistflex and the 5 HASN wires produced a range of broadly comparable results, and NiTi gave the highest unloading values. Model rankings indicated that self-ligating Twin-Lock brackets produced lower friction than regular edgewise brackets.

Farnaz Parvizi[34] EJO 2003 conducted a study to investigate the load/deflection characteristics of three commercially available

thermally active nickel–titanium orthodontic archwires using a standard nickel–titanium archwire as a control. The thermally active wires were Regency Thermal, Orthoform, and Eurotherm and the control was Memory. Round 0.4 mm and rectangular 0.4 × 0.56 mm wires were subjected to 2 and 4 mm of deflection in a water bath at temperatures of 20, 30, and 40°C and forces were measured in three-point bending test and phantom head test. It was fond that , irrespective of the test set up and wire type, wire size had a significant effect on the forces produced. An increase in size from 0.4 mm round to 0.4 × 0.56 mm rectangular wire approximately doubled the force values for a given deflection. The effect of wire deflection on the force values varied according to the test system, forces being much higher in the phantom head tests than in the 3-point bending test, in the which, an increase in wire deflection from 2 to 4 mm had no significant effect on the forces exerted, but in the phantom head tests the forces produced by each wire at 4 mm deflection were four to five times greater than those at 2 mm deflection. Each of the thermally active wires produced less force that the non-thermally active wire. In the 3 point bending tests each 10°C rise in temperature from 20 to 40°C had a highly significant effect on the force produced by each thermoelastic wire. In the phantom head tests there were significant force increases between 20 and 30°C, but between 30 and 40°C the forces did not change significantly.

Elda Gatto[35] et al EJO 2011 investigated the mechanical properties of superelastic and thermal nickel – titanium (NiTi) archwires for correct selection of orthodontic wires. Seven different NiTi wires of two different sizes (0.014 and 0.016 inches), were tested. A three-point bending test was carried out to evaluate the load – deflection characteristics. The archwires were subjected to bending at a constant temperature of 37°C and deflections of 2 and 4 mm. Analysis of variance showed that thermal NiTi wires exerted significantly lower working forces than superelastic wires of the same size in all experimental tests . Wire size had a significant effect on the forces produced, with an increase in archwire dimension, the stress exerted was also increased for both thermal and superelastic wires.. It was also concluded that in low-friction mechanics, thermal NiTi wires are to be preferred to superelastic wires, during the alignment phase due to their lower working forces.

Luca Lombardo[36] et al AO 2012 compared the characteristics of commonly used types of traditional and heat-activated initial archwire by plotting their load/deflection graphs and quantifying three suitable parameters describing the discharge plateau phase. Forty-eight archwires (22 nickel titanium [NiTi] and 26 heat-activated) of cross-sectional diameter ranging from 0.010 to 0.016 inch were obtained from seven different manufacturers. A modified three-point wire-bending test was performed on three analogous samples of each type of archwire at a constant temperature (37^0C).

For each resulting load/ deflection curve, the plateau section was isolated, along with the mean value of the average plateau force, the plateau length, and the plateau slope for each type of wire obtained. Statistically significant differences were found between almost all wires for the three parameters considered. Statistically significant differences were also found that the heat-activated archwires generated longer plateaus and lighter average forces than the superelastic NiTi archwires. It was also found that there is an increase in average force seen with increasing diameter.

Daniel Jogaib Fernandes[37] et al Materials Research 2015 conducted a study to compare the mechanical properties of commercially available NiTi orthodontic archwires lots. 0.014 inch Superelastic (SE) and heat-activated (HA) NiTi archwires from two lots of six manufacturers (3M, GAC, Tp, Orthosource, Orthometric and Morelli) were partitioned into eleven groups and tested under three-point bending tests. It was found that Heat activated archwires showed better mechanical performance than Superelastic archwires, with lower stress level on loading and unloading plateau ,thus lower forces is delivered to the tooth with Heat-activated NiTi wires.

Surachai Dechkunakorn[38] et al Applied Mechanics and Materials 2016 conducted a study to investigate the force exerted by superelastic NiTi wires for proper selection of orthodontic wires by

three-point bending tests, since light continuous force is more efficient and physiological for tooth movement. 14 different superelastic nickel-titanium orthodontic preformed lower arch wires with a nominal size of 0.016 x 0.022 inch were selected. The three-point bending test was conducted using the Lloyd Universal testing machine: LF Plus CS4921 was conducted with a mid-span deflection rate of 5 mm/min under constant temperature range 36±1C^{o}. Wires were deflected to 3.1 mm. All data were recorded during the unloading process at deflections 3, 2, 1 and 0.5 mm. It was found that there is a large variation of force exerted by different manufacturers with the unloading forces of Sentalloy being the lowest among the different brands of nickel-titanium alloy wires.

W. P. Rock[39] BJO 2016 conducted a study to measure the forces exerted by aligning archwires using a simulated clinical situation and also with three point loading test. A laboratory testing system was designed to reproduce as closely as possible the situation in the mouth. The teeth were well aligned and in good contact, except for the maxillary right central incisor which was removed. The teeth were fitted with 0.018 inch slot standard edgewise Siamese brackets. test assembly was mounted on the load cell of an Instron testing machine so that the force required to produce a given deflection could he measured . In order to compare the forces exerted by archwires with the performance of simple beams, a

separate series of tests was performed using a specially made jig. All tests were made to a maximum deflection of 3 mm. At 1·5 mm deflection the forces exerted by wires in simulated fixed appliance ranged from 1·5 to 8·3 N. When the same wires were used in three point bending test, the forces exerted ranged from 0·3 to 3·0 N. The findings indicate that the forces generated by orthodontic mechanisms cannot be calculated from straightforward physical principles.

Aphinan Phukaoluan[40] et al Key Engineering Materials 2017 conducted a study to address the amount of force delivered by a fabricated NiTiCu orthodontic wire with a ternary composition ratio of 46.0 Ni: 49.0 Ti: 5.0 Cu and to compare the results with a commercial NiTiCu35^{o}C orthodontic archwire. It was found that both NiTiCu wires presented typical superelastic properties as observed from the load-deflection curve. There were significant differences in mean loading and unloading forces between the two NiTiCu wires. The deflection forces in loading and unloading force for Ormco NiTiCu at each point were less than the fabricated NiTiCu except at the deflection point of 0.25 mm. Regarding the force difference between each deflection point of loading and unloading force, Ormco NiTiCu35^{o}C exerted less force than the fabricated NiTiCu, except at difference deflection at 1.5-1.25 mm of unloading force. It is concluded that the Ormco 35^{o}C NiTiCu performed well when compared to the fabricated NiTICu by exerting less stress on the tooth.

MATERIALS AND METHODS

STUDY DESIGN

Double blinded Prospective Clinical Trail

STUDY AREA

Department of Orthodontics and Dentofacial Orthopaedics, Madha Dental College & Hospital, Kundrathur, Chennai, TamilNadu, India.

STUDY POPULATION

The study was carried out on the patients reporting to the Department of Orthodontics and Dentofacial Orthopaedics, Madha Dental College & Hospital.

INCLUSION CRITERIA

- Age group 19 to 27 years.
- Eruption of mandibular teeth upto second molar.
- Patient's treatment plan which includes both non-extraction and therapeutic extraction of pre-molars.
- Little irregularity index score between 4 -9.
- Class – I skeletal pattern
- Treatment modality which does not include the placement of Transpalatal arch or Lingual arch which may cause discomfort.

EXCLUSION CRITERIA

- Congenitally missing or impacted lower anterior teeth.
- Periodontally compromised patients.
- Patients whose treatment plan included extraction of lower anterior teeth.
- Patients with blocked out lower anterior teeth that did not allow for the placement of bracket at the initial bonding appointment.
- Treatment plan which included the use of intermaxillary elastic, interproximal stripping and niti open coil spring to relieve the crowding.
- Previous history of active Orthodontic treatment.

ETHICAL CLEARANCE:

This study was approved by Institutional Review Board and Human Ethical Committee of Madha Medical College & Hospital.

SAMPLE SIZE

Sample size calculation on the basis of previous study[42] reveals that using at least 30 subjects would provide adequate statistical power (95%) to detect a significant difference between the three types of archwires. A total of 42 patients were examined. Eight patients were excluded from the trial because of not meeting the inclusion criteria. The overall study sample size consisted of 34 patients requiring fixed orthodontic appliance therapy for the

correction of malalignment. To compensate for nonresponsive and incomplete data, 4 additional patients were included. During the course of the study four patients did not report the debond of brackets within 24 hours and were excluded from the study. Therefore the final sample size was 30 with 10 patients in each group. All patients were matched according to the age, sex, degree of initial crowding and treatment modality(extraction and non-extraction).

ARMAMENTARIUM USED

The following materials and equipments were used for measuring the mandibular anterior irregularity:

1. Ormco mini 2000 MBT prescription stainless steel metal brackets - 0.022x0.028" slot.
2. 0.014" Forestadent Biostarter NiTi archwire
3. 0.014" 3M(Unitek) Heat-activated NiTi arch wire.
4. 0.014" 3M(Unitek) Superelastic Niti arch wires.
5. 3M (Unitek) elastomeric modules
6. Digital Vernier caliper.
7. Alginate impression material
8. DSLR Camera (Canon 1200D).
9. Armamentarium
10. Orthokal

For measuring the pain perception:

A specially designed 10 point Visual Analogue Scale (VAS) recording sheet which consists of 7 VAS scale of each 10 cm in length. Details for recording the analgesic consumption for all seven days were also included.**(Annexure- V)**

For measuring the stress distributed in archwire:

1. Instron 8874 machine
2. 0.014" Biostarter NiTi, 0.014" Heat-activated NiTi and 0.014" Superelastic Niti archwire used for the alignment of dentition for a period of 12 weeks

METHODOLOGY:

Method of patient allocation:

All the participants were informed about the nature and purpose of the study and a consent form was duly signed before commencement of treatment. All doubts of the patients regarding the study were clarified. Patients were selected for the study according to the inclusion criteria mentioned.

A total 30 patients were finally included in the study after the exclusions and dropouts and were matched according to the age, sex, degree of initial crowding, treatment modality and were distributed into 3 groups with 10 patients in each group -

In GROUP A - 0.014"Forestadent Biostarter NiTi

In GROUP B - 0.014" 3M(Unitek) Heat activated NiTi

In GROUP C -0.014" 3M(Unitek) Super elastic NiTi

Prior to the placement of the appliance, the impression of the lower arch was made using alginate impression material, models were poured using orthokal and occlusal photographs were taken.

Little's Irregularity Index:

Little described his irregularity Index in 1975[41]. It was used to assess the amount of crowding in the anterior region of mandibular arch. In this measurement system, the linear displacement of the anatomic contact points is measured from the mesial of the left mandibular canine to the mesial of the right mandibular canine. The measurements are performed in millimeters. In total, five measurements are made and then added together. Perfect alignment would have a score of zero. Greater the irregularity or malalignment, the greater is the score. The Irregularity Index represents the total distance that anatomic contact points would need to be moved in order to achieve ideal alignment. In this study the Little's Irregularity index was measured on the cast using a digital vernier caliper.

Little classified mandibular crowding into the following groups:

0 - Perfect alignment

1-3 - Minimal irregularity

4-6 - Moderate irregularity

7-9 - Severe irregularity

10 - Very severe irregularity

For the present study patient's with irregularity index score of 4 to 9 (Moderate to Severe) were chosen.

METHOD OF INVESTIGATION:

All the patients were bonded with 0.022x0.028" slot Ormco mini 2000 MBT prescription stainless steel metal brackets. In case of therapeutic extraction of lower premolars, bonding was done 3 weeks later, after the patient is completely out of extraction pain. Arch wires were placed in the lower arch in the same appointment after sterilizing in 2.0% chlorhexidine gluconate for 10 hours[43]. Arch wires were ligated using 3M elastomeric ligatures to engage the arch wires completely into the slot. If debonding occurred during treatment, rebonding was done within 24 hours; otherwise, it was considered a dropout. Also the pre-treatment alginate impression and occlusal photographs were taken before the start of the treatment.

At the routine follow-up appointment at 4 weeks, the wire was removed and alginate impression was made and occlusal photograph was taken. This alginate impression was then cast with stone. The archwires were ligated and activated with elastomeric modules. The whole procedure was repeated again at 8^{th} and 12^{th} week.

All readings were measured by a single operator, who was not aware of the archwire specimen used for the arches being measured. These readings were taken at 0-, 4-, 8-, and 12-week and were designated as T0, T1, T2, T3 respectively.

Identification number was assigned to each study model prior to measurement in order to mask the patient's name, archwire group, and the time point during study model analysis. The study models were re-matched to the patient and archwire group after data collection was completed.

The change in the tooth alignment of the six anterior teeth is measured in millimeters from the resultant casts using Little's irregularity index at each stage (T0, T1,T2,T3) using a digital vernier caliper.

Observer bias and Reproducibility :

Observer bias was reduced by ensuring that measurements were performed by a single examiner who was blinded to the

patient's allocated group. In order to assess the reliability of the examiner, all the study models were re-measured 4 weeks after the original measurements were taken. Intra-examiner reliability of measurements was assessed by determining the Reliability SD and 95% confidence intervals. **(Table-XXX)**

Assessment of Pain Perception:

Assessments of pain/discomfort were made in the morning on a daily basis over the first 7-day period after bonding by means of a 10-point visual analog scale (VAS) of 10 cm length. The maximum pain experienced by each patient was recorded by them. All of the patients received a recording sheet with seven visual analog scales and were given oral instructions on how to complete the VAS scale by marking the point on the line which they believed to best represent the maximum pain they experienced per day, with 0 indicating no pain and 10 indicating unbearable pain. Patients were reminded daily by a phone call or a text message to fill in the recording sheet and to bring it on their next visit. Patients were free to take analgesic as required. They were asked to report whether they had taken an analgesic during the recording period, and if so, when.

Assessment of Stress distribution:

After the completion of 12 weeks of alignment, the wires were removed from the patient's mouth and cleaned by a piece of

clean cotton, then immersed in 2.0% chlorhexidine gluconate for 10 hours, which does not alter the load-deflection characteristics of NiTi archwires as proved in the previous study[43] . The specimens with 0.014 inch diameter and 30 mm length were cut from the straighter section of the arch. Each specimen was tested using three point bending test.

Three point bending test were carried out with INSTRON 8874 machine fitted with the force capacity upto 25kN load cell. The machine was operated at a cross head speed of 6.0mm/min. Fulcrum and cutlass radii were 0.1mm. The distance between the supports were 10 mm. The tests were performed in flexion until a deflection of 3.1mm at 37^0C was reached, which is in accordance with International Organisation for Standardization for wires used in orthodontics ISO15841:2014. Heating was provided with a light bulb controlled by a rheostat. The loading and unloading flexural stress distributed in the archwires were measured.

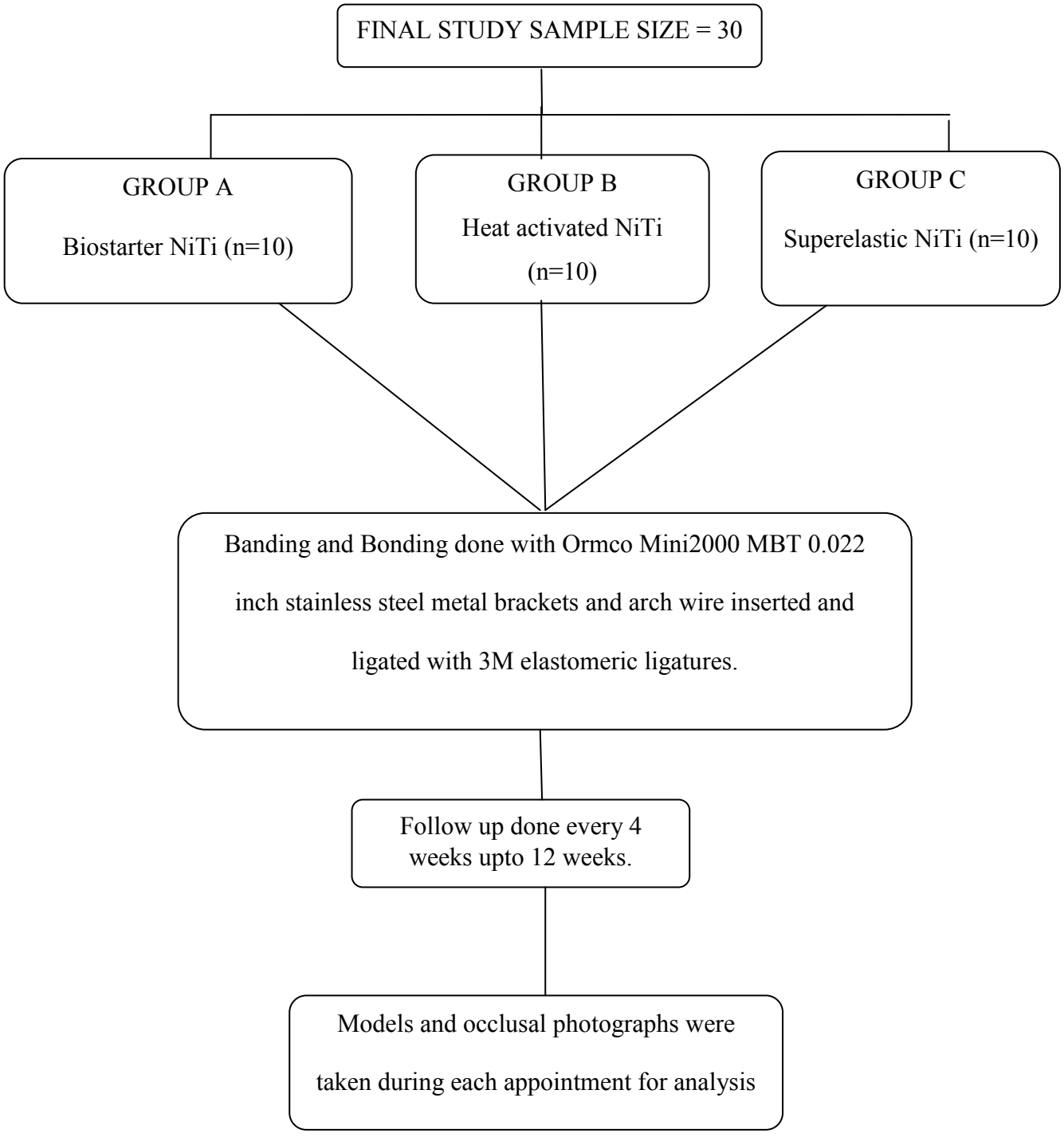
STATISTICAL ANALYSIS:

The following statistical analysis was done to evaluate the results using the software "Statistical package for social sciences" (IBM SPSS Statistics for Windows, Version 23.0, Armonk, NY: IBM Corp. Released 2015)

The Normality tests Kolmogorov-Smirnov and Shapiro-Wilks tests results reveal that the variables follow Normal distribution except stress. Therefore, to analyse the data Parametric and non-parametric methods are applied.

1. To compare mean values between groups one-way ANOVA is applied followed by Tukey's HSD post hoc tests for multiple pairwise comparisons.
2. To compare mean values between time points repeated measures ANOVA using General Linear Models is applied.
3. To compare proportions between groups Chi-Square test is applied, if any expected cell frequency is less than five then Fisher's exact test is used
4. For non-Normal variates (Stress values) to compare values between groups Kruskal Wallis test is used.

FLOW CHART - SAMPLING METHOD



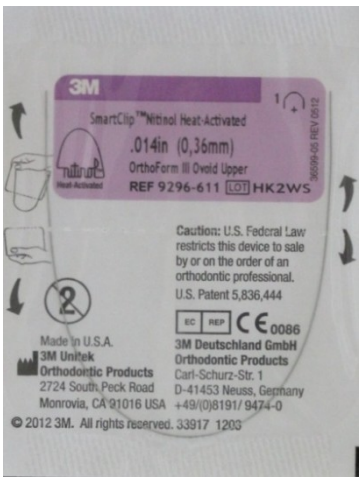
FIGURES

Color plate 1 - Archwires

Group- A

1a – Biostarter NiTi Archwire

Group-B



1b – Heat activated Niti archwire

Group-C

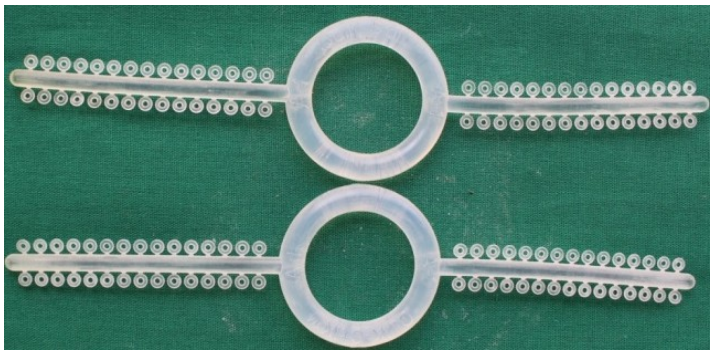
1c – Superelastic NiTi archwire

Color plate 2 – Materials Used

2a-Ormco mini 2000 stainless steel metal bracket kit

MBT 0.022 Prescription

2b-3M Modules



2c-Digital vernier caliper

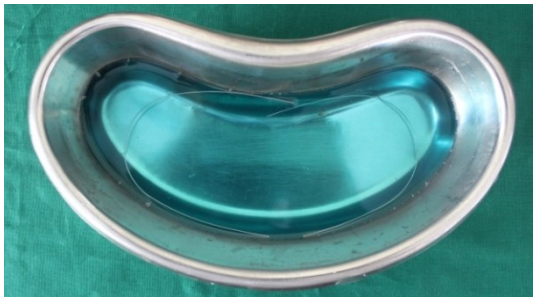
2d-Measurement of cast

2e - Armamentarium

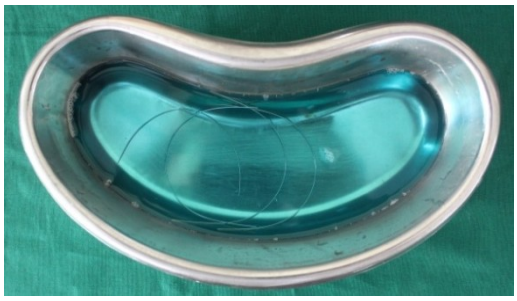
Color plate 3 -

3a - 2% Chlorhexidine Disinfectant

3b - Sterilization of archwires



Before inserting into patient's mouth



After removing from the patient's mouth

Colour Plate 4 – Patient Photographs

(4a): Group – A

Pre-Op:



4th week :



8th week:

12th week:

Group – B

(4b):

Pre-Op (T0):



4th week(T1):



8th week(T2):

12th week(T3):

Group – C

(4c):

Pre-Op(T0):

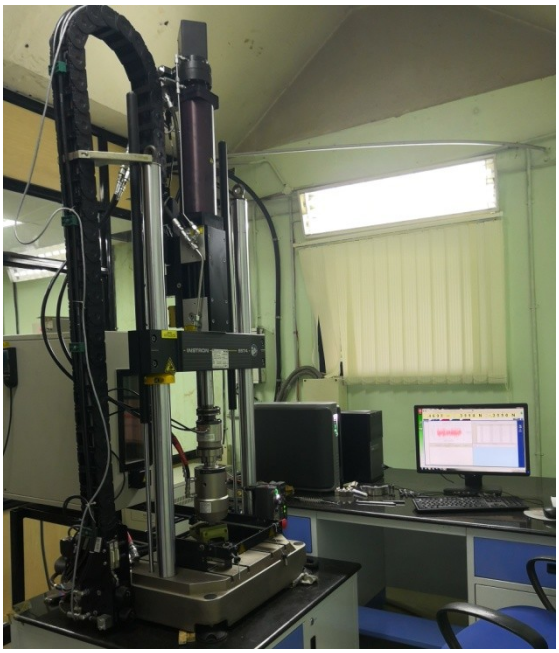
4th week(T1):

8th week(T2):

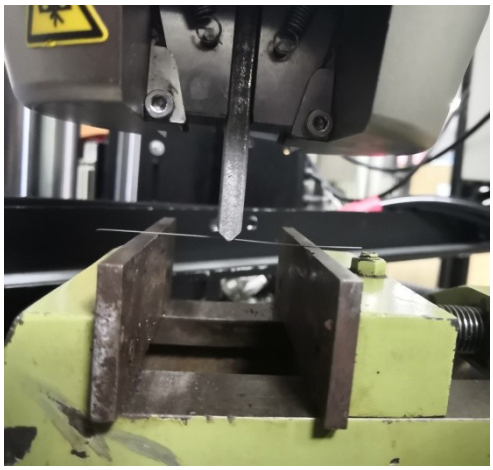
12th week(T3):

Color plate 5 – Three Point Bending Test

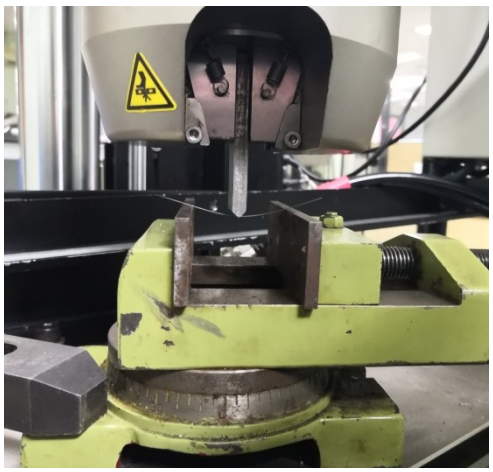
5a - Instron 8874



5b-Before Bending



5c-During Bending



RESULTS

A total of 42 patients were recruited. Eight patients were excluded from the trial because of not meeting the inclusion criteria. Four patients were excluded due to not reporting the debond of brackets within 24 hours. 30 patients were finally selected for the study.

They were divided into three groups.

i. Group-A comprises of patients receiving 0.014 inch BioStarter NiTi archwire.
ii. Group-B consisted of patients receiving 0.014 inch Heat activated NiTi archwire.
iii. Group-C consisted of patients receiving 0.014inch Superelastic NiTi archwire.

The baseline demographic and clinical characteristics for the three groups are shown in **Table 1.** In total, the sample consisted of 15 males and 15 females, with a mean age of 22.43years (standard deviation [SD], 2.46 years). The gender distribution is equal among the groups. There is no statistical significance observed in mean age between groups. Similarly the crowding and treatment modality is equally distributed between the groups to eliminate the confounding effects.

STATISTICAL ANALYSIS

The Normality tests Kolmogorov-Smirnov and Shapiro-Wilks tests results reveal that the variables follow Normal distribution except stress. Therefore, to analyse the data Parametric and non-parametric methods are applied. To compare mean values between groups one-way ANOVA is applied followed by Tukey's HSD post hoc tests for multiple pairwise comparisons. To compare mean values between interval repeated measures ANOVA using General Linear Models is applied. To compare proportions between groups Chi-Square test is applied, if any expected cell frequency is less than five then Fisher's exact test is used.For non-Normal variates (Stress values) to compare values between groups Kruskal Wallis test is used. To analyse the data SPSS (IBM SPSS Statistics for Windows, Version 23.0, Armonk, NY: IBM Corp. Released 2015) is used. Significance level is fixed as 5% ($\alpha = 0.05$).

OVERALL UNRAVELING EFFICIENCY

Within each group, the mean irregularity score has reduced significantly over time. **(Graph 1)**

Table –II and III represents the mean irregularity scores separately at all interval .No statistically significant differences were found at pre-op, 4th week but significant difference was found at 8^{th} week between groups by one way ANOVA. Group-A significantly differs between group B and group C ; but there is no significant difference observed between group B and group C . At

12^{th} week group-A significantly differs between group C ; but there is no significant difference observed between group-A and group-B & between group-B and group-C .

Table IV, V , VI represents the mean irregularity score between different interval of each group. The results reveal that there is statistical significance in the amount of decrowding between each interval within the three groups and shows that each wire has performed well in decrowding the irregularity within their groups .

Table VII represents the repeated measures ANOVA test using General Linear Models ,which confirms that there is no statistical significance seen in the performance among the three archwire types in aligning the irregularity. **(P = 0.64)**

UNRAVELING EFFICIENCY IN EXTRACTION AND NON –EXTRACTION CASES

Within each group, the mean irregularity score has reduced significantly over time **(Graph 2 & 3)** in both extraction and non-extraction patients.

Table VIII and IX represents the mean irregularity scores separately at each time point. In both extraction and non-extraction patients, no statistically significant differences among the three groups were found at pre-op, 4^{th} week and 12^{th} week but significant difference was found at 8^{th} week between groups by one-way ANOVA. Group-A significantly differs between group B and group

C; but there is no significant difference observed between group-B group-C (Tukey HSD Multiple Comparison).

Table X, XI, XII represents the mean irregularity between different interval of each group. The results reveal that there is statistical significance in the amount of decrowding between each interval among the three different archwires in both extraction and non-extraction patients and shows that each wire has performed well in decrowding the irregularity within their groups .

Table XIII represents a test using General Linear Models (Repeated measures ANOVA) confirmed that there is no statistical significance seen in the performance among the three archwire types in aligning the irregularity in both extraction**(P=0.130)** and non-extraction patients**(P=0.484)**

PAIN PERCEPTION

Table XIV represents the General Linear Model (Repeated Measures ANOVA) to compare mean pain scores between the interval and groups on each day. The table reveals that the mean pain score of Group-A is the least among the three groups on all the days. It also reveals that there no pain felt by the patient on the 7^{th} day in any of the groups.

Table XV represents the repeated measures ANOVA results, which shows that there is a significant difference in the mean pain score between groups**(P<0.01)**

Table XVI represents Bonferroni Post Hoc Test results, which shows that each group significantly differs in mean pain score from other groups.

Table XVII represents General Linear Model (Repeated Measures ANOVA) to compare mean pain scores between interval in each group separately. The table reveals that the mean pain score of all the three groups declines from day 1 to day 7.

Table XVIII and Table XIX represents the comparison of Day 1 mean pain score with subsequent day's mean pain scores in each group. The tables reveal that the mean pain score in each group has significantly declined from day 1 to day 7. The mean pain score of each group reveals that, Group-A has the least pain when compared to the other two group.

Table XX represents the One-way ANOVA to compare mean pain scores between groups at each time point. The table reveals that there is a significant difference in the mean pain score among the three groups every day

Table XXI represents the Tukey HSD Post Hoc Tests Multiple Comparisons**.** The table reveals that there is a significant difference in the mean pain score among the three groups every day except on day2, day3 and day4 between group B and group C & on day 6 between group A and group B. There is no pain felt by the patient on the 7^{th} day in any of the groups.

Graph 4 represents the mean pain score of the three groups from day 1 to day 7

Table XXII and XXIII represents the Chi-Square test to compare proportion of analgesic consumption between the groups on day 1.The tables reveal that highest percentage of analgesic consumption is seen in group-C and also there is a statistical significance between group-A and group-C on day 1.

Table XXIV and XXV represents the Chi-Square test to compare proportion of analgesic consumption between the groups on day 2.The tables reveal that highest percentage of analgesic consumption is seen in group-C but there is no statistical significance between any groups on day 2.

Graph 5 represents the analgesic consumption on day 1 and day 2.

Table XXVI and XXVII represents the Chi-Square test to compare the overall proportion of analgesic consumption between the groups on day 1 and day 2.

Graph 6 represents the overall analgesic consumption in the three groups.

On comparing the day 1 and day 2 analgesic consumption, the analgesic requirement has come down from day 1 to day 2 in all the three groups..It has been found that no patients from group-A has consumed analgesics on both the days. In Group-B and Group-C the

patients have consumed analgesics only on day 1 and 2. Patients have not consumed analgesic thereafter in any of the groups. On the whole, the drug consumption in Group-A is the least and it is statistically significant than Group-C. There is no significance between Group-B and Group-C

FLEXURAL STRESS DISTRIBUTION

Table XXVIII represents Kruskal-Wallis Test to compare flexural stress values of the archwires between groups. The table reveals that the Bio-starter NiTi arch wire belonging to Group-A exerted the least loading and unloading flexural stress among the three NiTi archwires but the mean stress value of Bio-starter NiTi archwire is not statistically significant between the three archwires in both loading**(P=0.107)** and unloading situations**(P=0.070)**.

Graph 7 represents the mean loading and unloading flexural stress values of the three archwires.

Table - I: shows the demographic details and clinical characteristics of three groups

		Bio-Starter Low friction NiTi N = 10	Heat activated NiTi N = 10	NitinolSuperelastic NiTi N = 10
Gender	Male	5	5	5
	Female	5	5	5
Age	19 – 27 years	22.5	22.2	22.6
Initial crowding	Moderate 4-6	5	5	5
	Severe 7-9	5	5	5
Treatment Modality	Extraction	5	5	5
	Non - Extraction	5	5	5

Table – II: shows the one-way ANOVA to compare mean alignment values between groups at each interval

Crowding Alignment	Group	N	Mean	Std. Dev	p-value
Crowding Alignment: Pre-OP	Group-A	10	6.910	1.6079	0.977 *(NS)*
	Group-B	10	6.910	1.5502	
	Group-C	10	6.780	1.4703	
Crowding Alignment: 4^{th} week	Group-A	10	3.340	1.7840	0.296 *(NS)*
	Group-B	10	4.270	1.9073	
	Group-C	10	4.340	.7152	
Crowding Alignment: 8^{th} week	Group-A	10	.400	.8894	0.000 *(Sig)*
	Group-B	10	2.180	.7983	
	Group-C	10	2.290	1.0093	
Crowding Alignment: 12^{th} week	Group-A	10	.000	.0000	0.020 *(Sig)*
	Group-B	10	.640	.8720	
	Group-C	10	.910	.8319	

Table – III: Tukey HSD Multiple Comparisons shows the unravelling efficiency between the groups at 8th and 12th week

Variable	Group		Mean Difference	p-value
Crowding Alignment: 8th week	Group-A	Group-B	-1.7800	.000*(Sig)*
		Group-C	-1.8900	.000*(Sig)*
	Group-B	Group-C	-.1100	.960 *(NS)*
Crowding Alignment: 12th week	Group-A	Group-B	-.6400	.118 *(NS)*
		Group-C	-.9100	.018*(Sig)*
	Group-B	Group-C	-.2700	.665 *(NS)*

Table - IV: General Linear Model (Repeated Measures ANOVA) to compare mean crowding alignment values in each group

Descriptive Statistics

Group	Crowding Alignment	N	Mean	Std. Dev
Group-A	Pre-OP	10	6.910	1.6079
	4thweek	10	3.340	1.7840
	8thweek	10	.400	.8894
	12thweek	10	.000	.0000
Group-B	Pre-OP	10	6.910	1.5502
	4thweek	10	4.270	1.9073
	8thweek	10	2.180	.7983
	12thweek	10	.640	.8720
Group-C	Pre-OP	10	6.780	1.4703
	4thweek	10	4.340	.7152
	8thweek	10	2.290	1.0093
	12thweek	10	.910	.8319

Table - V: Mean irregularity score between the intervals in each group - Tests of Within-Subjects Effects

Group	Source	Type III Sum of Squares	df	Mean Square	p-value
Group-A	Alignment	307.081	3	102.360	.000*(Sig)*
	Error	26.552	27	.983	
Group-B	Alignment	221.430	3	73.810	.000*(Sig)*
	Error	25.450	27	.943	
Group-C	Alignment	196.106	3	65.369	.000*(Sig)*
	Error	21.754	27	.806	

Table - VI: Comparison of each interval with pre-op

Tests of Within-Subjects Contrasts

Group	Alignment	Type III Sum of Squares	df	Mean Square	p-value
Group-A	4thweek vs. Pre-OP	127.449	1	127.449	.000*(Sig)*
	8thweek vs. Pre-OP	423.801	1	423.801	.000*(Sig)*
	12thweek vs. Pre-OP	477.481	1	477.481	.000*(Sig)*
Group-B	4thweek vs. Pre-OP	69.696	1	69.696	.000*(Sig)*
	8thweek vs. Pre-OP	223.729	1	223.729	.000*(Sig)*
	12thweek vs. Pre-OP	393.129	1	393.129	.000*(Sig)*
Group-C	4thweek vs. Pre-OP	59.536	1	59.536	.000*(Sig)*
	8thweek vs. Pre-OP	201.601	1	201.601	.000*(Sig)*
	12thweek vs. Pre-OP	344.569	1	344.569	.000*(Sig)*

Table - VII: Repeated measures ANOVA test using General Linear Models confirms that there is no statistical significance seen in the performance among the three archwire types in aligning the irregularity.

Source	Type III Sum of Squares	df	Mean Square	p-value
Intercept	316.388	1	316.388	.064 *(NS)*
Group	5.165	2	2.583	
Error	22.921	27	.849	

Table - VIII: shows the one-way ANOVA to compare mean alignment values between groups at each interval in extraction and non-extraction treatment modalities

Modality	Variables	Group	N	Mean	Std. Dev	p-value
Extraction	Crowding Alignment: Pre-OP	Group-A	5	7.200	1.5524	.951 *(NS)*
		Group-B	5	7.500	1.5116	
		Group-C	5	7.420	1.5770	
	Crowding Alignment: 4thweek	Group-A	5	3.220	.6648	.312 *(NS)*
		Group-B	5	4.320	2.0535	
		Group-C	5	4.380	.5586	
	Crowding Alignment: 8thweek	Group-A	5	.280	.6261	.014*(Sig)*
		Group-B	5	2.160	.7956	
		Group-C	5	2.400	1.4816	
	Crowding Alignment: 12thweek	Group-A	5	.000	.0000	.218 *(NS)*
		Group-B	5	.760	1.0784	
		Group-C	5	.800	.7714	
Non-Extraction	Crowding Alignment: Pre-OP	Group-A	5	6.620	1.7880	.880 *(NS)*
		Group-B	5	6.320	1.5007	
		Group-C	5	6.140	1.1632	
	Crowding Alignment: 4thweek	Group-A	5	3.460	2.5851	.760 *(NS)*
		Group-B	5	4.220	1.9905	
		Group-C	5	4.300	.9138	
	Crowding Alignment: 8thweek	Group-A	5	.520	1.1628	.014*(Sig)*
		Group-B	5	2.200	.8944	
		Group-C	5	2.180	.2588	
	Crowding Alignment: 12thweek	Group-A	5	.000	.0000	.107 *(NS)*
		Group-B	5	.520	.7155	
		Group-C	5	1.020	.9654	

Table - IX: Comparison between the groups for significance in unravelling at 8th week

Tukey HSD Multiple Comparisons-

Modality	Variable	Group		Mean Difference	p-value
Extraction	Crowding Alignment: 8thweek	Group-A	Group-B	-1.8800	.035*(Sig)*
			Group-C	-2.1200	.018*(Sig)*
		Group-B	Group-C	-.2400	.929 *(NS)*
Non-Extraction	Crowding Alignment: 8thweek	Group-A	Group-B	-1.6800	.024*(Sig)*
			Group-C	-1.6600	.025*(Sig)*
		Group-B	Group-C	.0200	.999 *(NS)*

Table - X: General Linear Model (Repeated Measures ANOVA) to compare mean crowding alignment values in each group

Descriptive Statistics

Group	Modality	Crowding Alignment	N	Mean	Std. Dev
Group-A	Extraction	Pre-OP	5	7.200	1.5524
		4thweek	5	3.220	.6648
		8thweek	5	.280	.6261
		12thweek	5	.000	.0000
	Non-Extraction	Pre-OP	5	6.620	1.7880
		4thweek	5	3.460	2.5851
		8thweek	5	.520	1.1628
		12thweek	5	.000	.0000
Group-B	Extraction	Pre-OP	5	7.500	1.5116
		4thweek	5	4.320	2.0535
		8thweek	5	2.160	.7956
		12thweek	5	.760	1.0784
	Non-Extraction	Pre-OP	5	6.320	1.5007
		4thweek	5	4.220	1.9905
		8thweek	5	2.200	.8944
		12thweek	5	.520	.7155
Group-C	Extraction	Pre-OP	5	7.420	1.5770
		4thweek	5	4.380	.5586
		8thweek	5	2.400	1.4816
		12thweek	5	.800	.7714
	Non-Extraction	Pre-OP	5	6.140	1.1632
		4thweek	5	4.300	.9138
		8thweek	5	2.180	.2588
		12thweek	5	1.020	.9654

Table - XI: shows that the mean irregularity score has significantly reduced between the intervals in each group - Tests of Within-Subjects Effects

Group	Modality	Source	Type III Sum of Squares	df	Mean Square	p-value
Group-A	Extraction	Alignment	168.322	3	56.107	.000*(Sig)*
		Error	7.476	12	.623	
	Non-Extraction	Alignment	139.882	3	46.627	.000*(Sig)*
		Error	17.953	12	1.496	
Group-B	Extraction	Alignment	129.194	3	43.065	.000*(Sig)*
		Error	13.044	12	1.087	
	Non-Extraction	Alignment	94.521	3	31.507	.000*(Sig)*
		Error	10.121	12	.843	
Group-C	Extraction	Alignment	121.954	3	40.651	.000*(Sig)*
		Error	12.131	12	1.011	
	Non-Extraction	Alignment	77.350	3	25.783	.000*(Sig)*
		Error	6.425	12	.535	

Table - XII: Comparison of each interval with pre-op

Tests of Within-Subjects Contrasts

Group	Modality	Alignment	Type III Sum of Squares	df	Mean Square	p-value
Group-A	Extraction	Pre-OP vs. 4thweek	79.202	1	79.202	.003*(Sig)*
		Pre-OP vs. 8thweek	239.432	1	239.432	.000*(Sig)*
		Pre-OP vs. 12thweek	259.200	1	259.200	.000*(Sig)*
	Non-Extraction	Pre-OP vs. 4thweek	49.928	1	49.928	.004*(Sig)*
		Pre-OP vs. 8thweek	186.050	1	186.050	.001*(Sig)*
		Pre-OP vs. 12thweek	219.122	1	219.122	.001*(Sig)*
Group-B	Extraction	Pre-OP vs. 4thweek	50.562	1	50.562	.001*(Sig)*
		Pre-OP vs. 8thweek	142.578	1	142.578	.000*(Sig)*
		Pre-OP vs. 12thweek	227.138	1	227.138	.001*(Sig)*
	Non-Extraction	Pre-OP vs. 4thweek	22.050	1	22.050	.009*(Sig)*
		Pre-OP vs. 8thweek	84.872	1	84.872	.003*(Sig)*
		Pre-OP vs. 12thweek	168.200	1	168.200	.000*(Sig)*
Group-C	Extraction	Pre-OP vs. 4thweek	46.208	1	46.208	.005*(Sig)*
		Pre-OP vs. 8thweek	126.002	1	126.002	.007*(Sig)*
		Pre-OP vs. 12thweek	219.122	1	219.122	.001*(Sig)*
	Non-Extraction	Pre-OP vs. 4thweek	16.928	1	16.928	.002*(Sig)*
		Pre-OP vs. 8thweek	78.408	1	78.408	.001*(Sig)*
		Pre-OP vs. 12thweek	131.072	1	131.072	.001*(Sig)*

Table - XIII: A Repeated measures ANOVA test using General Linear Models confirmed that there is no statistical significance seen in the performance among the three archwire types in aligning the irregularity in both extraction and non-extraction treatment modalities

Modality	Source	Type III Sum of Squares	df	Mean Square	p-value
Extraction	Intercept	170.354	1	170.354	.130 *(NS)*
	Group	3.633	2	1.817	
	Error	8.968	12	.747	
Non-Extraction	Intercept	146.484	1	146.484	.484 *(NS)*
	Group	1.715	2	.857	
	Error	13.320	12	1.110	

Table - XIV: General Linear Model (Repeated Measures ANOVA) to compare mean pain scoresbetween the time points and groups on each day

Descriptive Statistics

Pain Score	Group	N	Mean	Std. Dev
Day 1	Group-A	10	5.30	1.059
	Group-B	10	8.20	.789
	Group-C	10	9.40	.699
	Total	30	7.63	1.938
Day 2	Group-A	10	3.60	1.350
	Group-B	10	7.10	.994
	Group-C	10	8.20	1.317
	Total	30	6.30	2.322
Day 3	Group-A	10	1.80	1.229
	Group-B	10	5.70	1.160
	Group-C	10	6.70	1.889
	Total	30	4.73	2.572
Day 4	Group-A	10	.50	.707
	Group-B	10	3.90	1.101
	Group-C	10	5.20	1.751
	Total	30	3.20	2.355
Day 5	Group-A	10	.00	.000
	Group-B	10	1.70	.675
	Group-C	10	3.50	1.434
	Total	30	1.73	1.701
Day 6	Group-A	10	.00	.000
	Group-B	10	.00	.000
	Group-C	10	1.30	1.160
	Total	30	.43	.898
Day 7	Group-A	10	.00	.000
	Group-B	10	.00	.000
	Group-C	10	.00	.000
	Total	30	.00	.000

Table - XV: Repeated measures ANOVA shows that there is a significant difference in the mean pain score between groups

Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	p-value
Intercept	353.633	1	353.633	.000*(Sig)*
Group	56.467	2	28.233	
Error	15.880	27	.588	

Table XVI - Bonferroni Post Hoc Test results shows that each group significantly differs in mean pain score from other groups.

Group		Mean Difference	p-value
Group-A	Group-B	-2.20	.000*(Sig)*
	Group-C	-3.30	.000*(Sig)*
Group-B	Group-C	-1.10	.010*(Sig)*

Table - XVII: General Linear Model (Repeated Measures ANOVA) to compare mean pain scores between time points in each group separately

Descriptive Statistics

Group	Pain Score	N	Mean	Std. Dev
Group-A	Day 1	10	5.30	1.059
	Day 2	10	3.60	1.350
	Day 3	10	1.80	1.229
	Day 4	10	.50	.707
	Day 5	10	.00	.000
	Day 6	10	.00	.000
	Day 7	10	.00	.000
Group-B	Day 1	10	8.20	.789
	Day 2	10	7.10	.994
	Day 3	10	5.70	1.160
	Day 4	10	3.90	1.101
	Day 5	10	1.70	.675
	Day 6	10	.00	.000
	Day 7	10	.00	.000
Group-C	Day 1	10	9.40	.699
	Day 2	10	8.20	1.317
	Day 3	10	6.70	1.889
	Day 4	10	5.20	1.751
	Day 5	10	3.50	1.434
	Day 6	10	1.30	1.160
	Day 7	10	.00	.000

Table - XVIII: represents the comparison of Day 1 mean pain score with subsequent day's mean pain scores in each group.

Group	Pain Score	Type III Sum of Squares	df	Mean Square	p-value
Group-A	Day 1vs. Day 2	28.900	1	28.900	.000*(Sig)*
	Day 1vs. Day 3	122.500	1	122.500	.000*(Sig)*
	Day 1vs. Day 4	230.400	1	230.400	.000*(Sig)*
	Day 1vs. Day 5	280.900	1	280.900	.000*(Sig)*
	Day 1vs. Day 6	280.900	1	280.900	.000*(Sig)*
	Day 1vs. Day 7	280.900	1	280.900	.000*(Sig)*
Group-B	Day 1vs. Day 2	12.100	1	12.100	.007*(Sig)*
	Day 1vs. Day 3	62.500	1	62.500	.000*(Sig)*
	Day 1vs. Day 4	184.900	1	184.900	.000*(Sig)*
	Day 1vs. Day 5	422.500	1	422.500	.000*(Sig)*
	Day 1vs. Day 6	672.400	1	672.400	.000*(Sig)*
	Day 1vs. Day 7	672.400	1	672.400	.000*(Sig)*
Group-C	Day 1vs. Day 2	14.400	1	14.400	.001*(Sig)*
	Day 1vs. Day 3	72.900	1	72.900	.000*(Sig)*
	Day 1vs. Day 4	176.400	1	176.400	.000*(Sig)*
	Day 1vs. Day 5	348.100	1	348.100	.000*(Sig)*
	Day 1vs. Day 6	656.100	1	656.100	.000*(Sig)*
	Day 1vs. Day 7	883.600	1	883.600	.000*(Sig)*

Table - XIX: Tests between three group for significance

Group	Source	Type III Sum of Squares	df	Mean Square	p-value
Group-A	Pain Score	266.200	6	44.367	.000*(Sig)*
	Error	26.371	54	.488	
Group-B	Pain Score	671.600	6	111.933	.000*(Sig)*
	Error	21.543	54	.399	
Group-C	Pain Score	734.000	6	122.333	.000*(Sig)*
	Error	37.429	54	.693	

Table - XX: One-way ANOVA to compare mean pain scores between groups at each interval

Pain Score	Group	N	Mean	Std. Dev	p-value
Day 1	Group-A	10	5.30	1.059	.000 *(Sig)*
	Group-B	10	8.20	.789	
	Group-C	10	9.40	.699	
Day 2	Group-A	10	3.60	1.350	.000 *(Sig)*
	Group-B	10	7.10	.994	
	Group-C	10	8.20	1.317	
Day 3	Group-A	10	1.80	1.229	.000 *(Sig)*
	Group-B	10	5.70	1.160	
	Group-C	10	6.70	1.889	
Day 4	Group-A	10	.50	.707	.000 *(Sig)*
	Group-B	10	3.90	1.101	
	Group-C	10	5.20	1.751	
Day 5	Group-A	10	.00	.000	.000 *(Sig)*
	Group-B	10	1.70	.675	
	Group-C	10	3.50	1.434	
Day 6	Group-A	10	.00	.000	.000 *(Sig)*
	Group-B	10	.00	.000	
	Group-C	10	1.30	1.160	
Day 7	Group-A	10	.00	.000	-
	Group-B	10	.00	.000	
	Group-C	10	.00	.000	

Table - XXI: To compare the significance between the groups each day - Tukey HSD Post Hoc Tests Multiple Comparisons

Variable	Group		Mean Difference	p-value
Pain Score: Day 1	Group-A	Group-B	-2.900	.000*(Sig)*
		Group-C	-4.100	.000*(Sig)*
	Group-B	Group-C	-1.200	.012*(Sig)*
Pain Score: Day 2	Group-A	Group-B	-3.500	.000*(Sig)*
		Group-C	-4.600	.000*(Sig)*
	Group-B	Group-C	-1.100	.132 *(NS)*
Pain Score: Day 3	Group-A	Group-B	-3.900	.000*(Sig)*
		Group-C	-4.900	.000*(Sig)*
	Group-B	Group-C	-1.000	.294 *(NS)*
Pain Score: Day 4	Group-A	Group-B	-3.400	.000*(Sig)*
		Group-C	-4.700	.000*(Sig)*
	Group-B	Group-C	-1.300	.072 *(NS)*
Pain Score: Day 5	Group-A	Group-B	-1.700	.001*(Sig)*
		Group-C	-3.500	.000*(Sig)*
	Group-B	Group-C	-1.800	.000*(Sig)*
Pain Score: Day 6	Group-A	Group-B	.000	.999 *(NS)*
		Group-C	-1.300	.001*(Sig)*
	Group-B	Group-C	-1.300	.001*(Sig)*

Table - XXII and XXIII: represents the Chi-Square test to compare proportion of analgesic consumption between the groups on day 1

Table XXII

Drug Consumption: Day 1	Group					
	Group-A		Group-B		Group-C	
	N	%	N	%	N	%
No	10	100.0	7	70.0	4	40.0
Yes	0	.0	3	30.0	6	60.0
Total	10	100.0	10	100.0	10	100.0

Table XXIII

Chi-Square Test		p-value
Fisher's Exact Test	Overall	0.016*(Sig)*
Fisher's Exact Test	A vs B	0.211*(NS)*
Fisher's Exact Test	A vs C	0.011*(Sig)*
Fisher's Exact Test	B Vs C	0.367*(NS)*

Table - XXIV and XXV: represents the Chi-Square test to compare proportion of analgesic consumption between the groups on day 2

Table XXIV

Drug Consumption: Day 2	Group					
	Group-A		Group-B		Group-C	
	N	%	N	%	N	%
No	10	100.0	9	90.0	7	70.0
Yes	0	.0	1	10.0	3	30.0
Total	10	100.0	10	100.0	10	100.0

Table XXV

Chi-Square Test		p-value
Fisher's Exact Test	Overall	0.286 *(NS)*
Fisher's Exact Test	A vs B	0.999 *(NS)*
Fisher's Exact Test	A vs C	0.211 *(NS)*
Fisher's Exact Test	B Vs C	0.582 *(NS)*

Table - XXVI and XXVII: Chi-Square test to compare the overall proportion of analgesic consumption between the groups on day 1 and day 2.

Table XXVI

Drug Consumption	Group					
	Group-A		Group-B		Group-C	
	N	%	N	%	N	%
No	10	100.0	7	70.0	4	40.0
Yes	0	.0	3	30.0	6	60.0
Total	10	100.0	10	100.0	10	100.0

Table XXVII

Chi-Square Test		p-value
Fisher's Exact Test	Overall	0.016*(Sig)*
Fisher's Exact Test	A vs B	0.211 *(NS)*
Fisher's Exact Test	A vs C	0.011 *(Sig)*
Fisher's Exact Test	B Vs C	0.367 *(NS)*

Table - XXVIII: Kruskal-Wallis Test to compare stress values of the archwires between groups

Descriptive Statistics

		Group			P Value
		Group-A	Group-B	Group-C	
Loading flexural stress	N	10	10	10	0.107(NS)
	Mean	90.3	96.0	123.1	
	Std. Dev	5.7	19.6	53.8	
	Median	90.6	90.6	109.2	
	4th Quartile	87.2	80.6	100.2	
	12th quartile	94.9	102.5	112.7	
Unloading flexural stress	N	10	10	10	0.070(NS)
	Mean	47.7	54.7	79.4	
	Std. Dev	14.7	40.0	28.3	
	Median	51.0	37.1	92.8	
	4th Quartile	47.1	22.7	70.1	
	12th quartile	54.8	77.7	99.6	

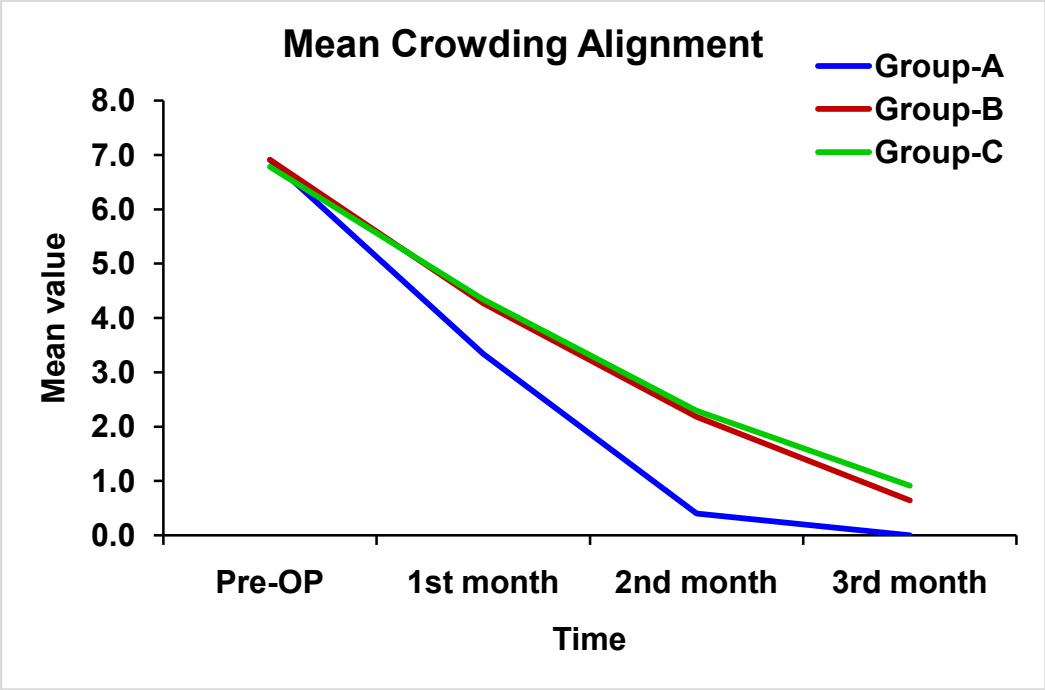
Table - XXIX: Mean scores

S.No		Biostarter NiTi (N=10)	Heat activated NiTi (N=10)	Superelastic NiTi (N=10)
1	Average crowding unraveled (T0-T3)	2.66 mm	3 mm	3.58 mm
2	Average pain perception(Day1-7)	1.6	3.8	4.94
3	Mean Loading stress	90.3 MPa	96 MPa	123.1 MPa
4	Mean Unloading stress	47.7 MPa	54.7 MPa	79.4 MPa

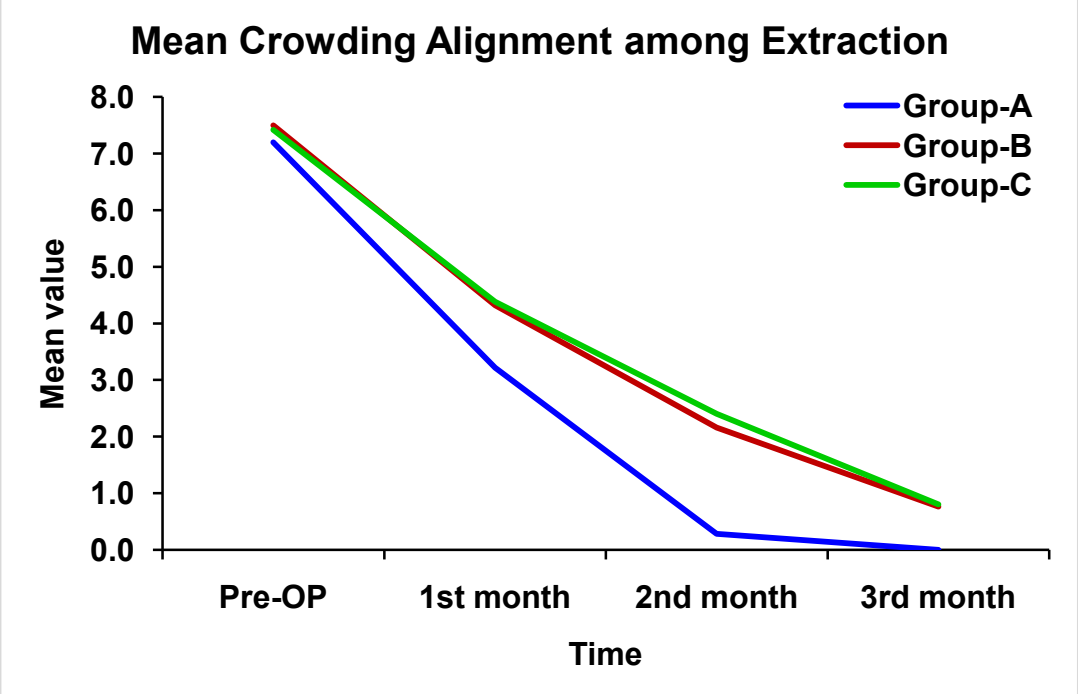
Table - XXX - Reproducibility measurements

Time points	Reliability SD	95% limits of agreement	
		Lower	Upper
Pre-OP	.000316	-.000326	.000126
1st month	.0420872	-.0502574	.0099574
2nd month	.0316	-.0326	.0126
3rd month	.0000316	-.0000326	.0000126

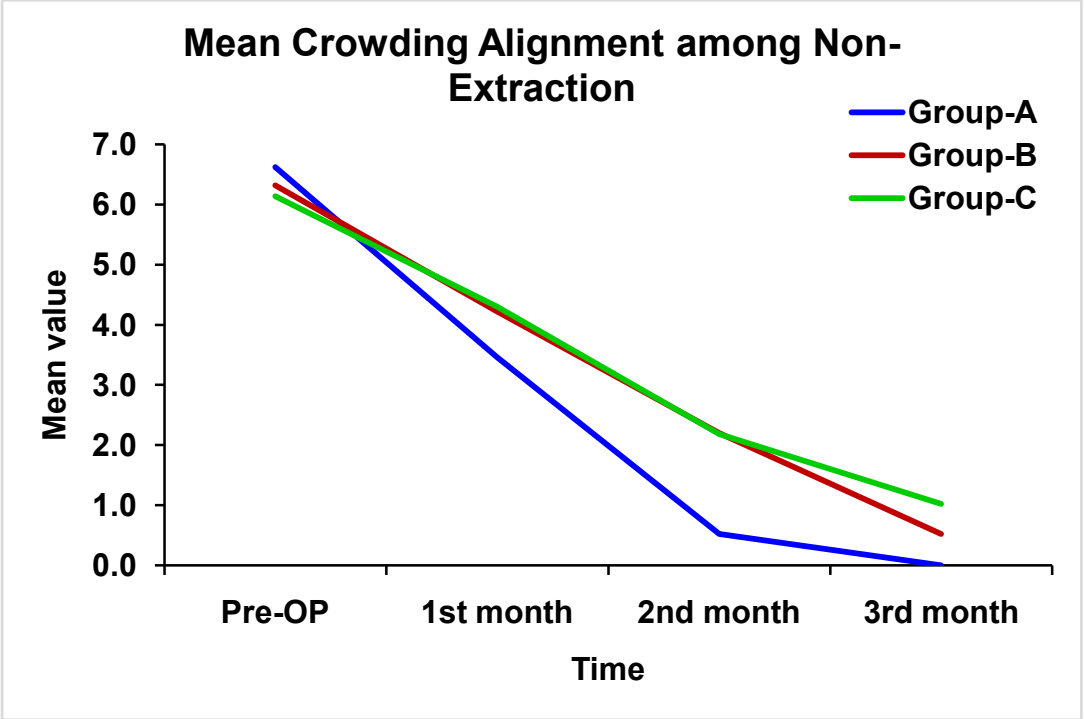
Graph 1 - Overall mean irregularity score of three archwires



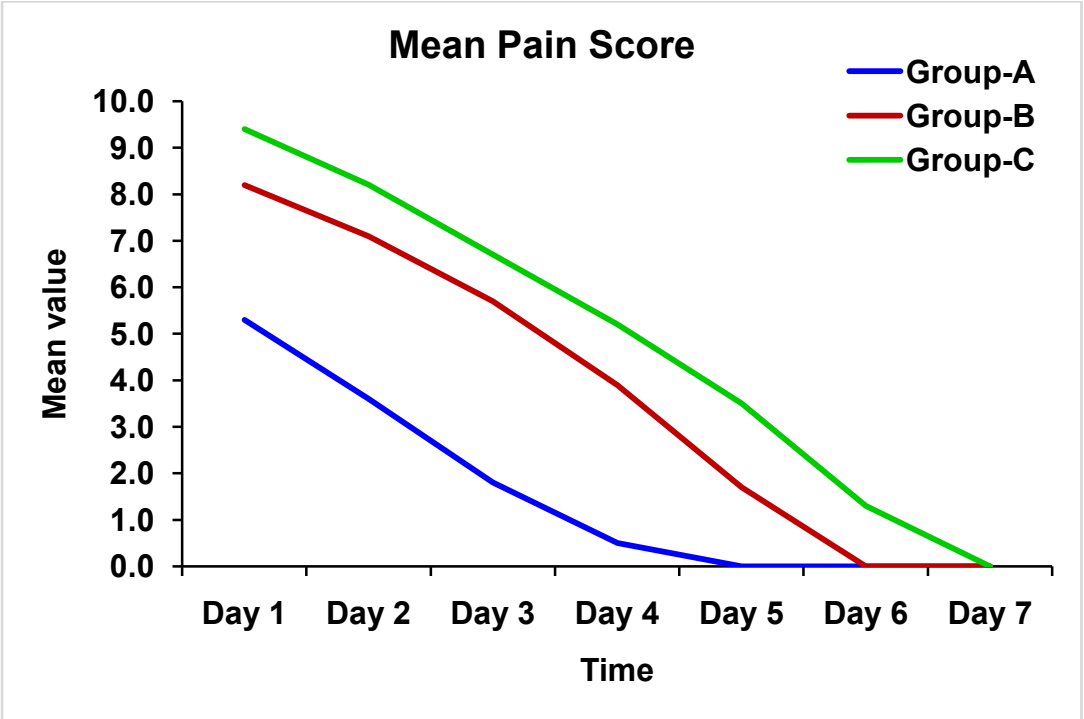
Graph 2 - Mean irregularity score of three archwires in extraction patients.



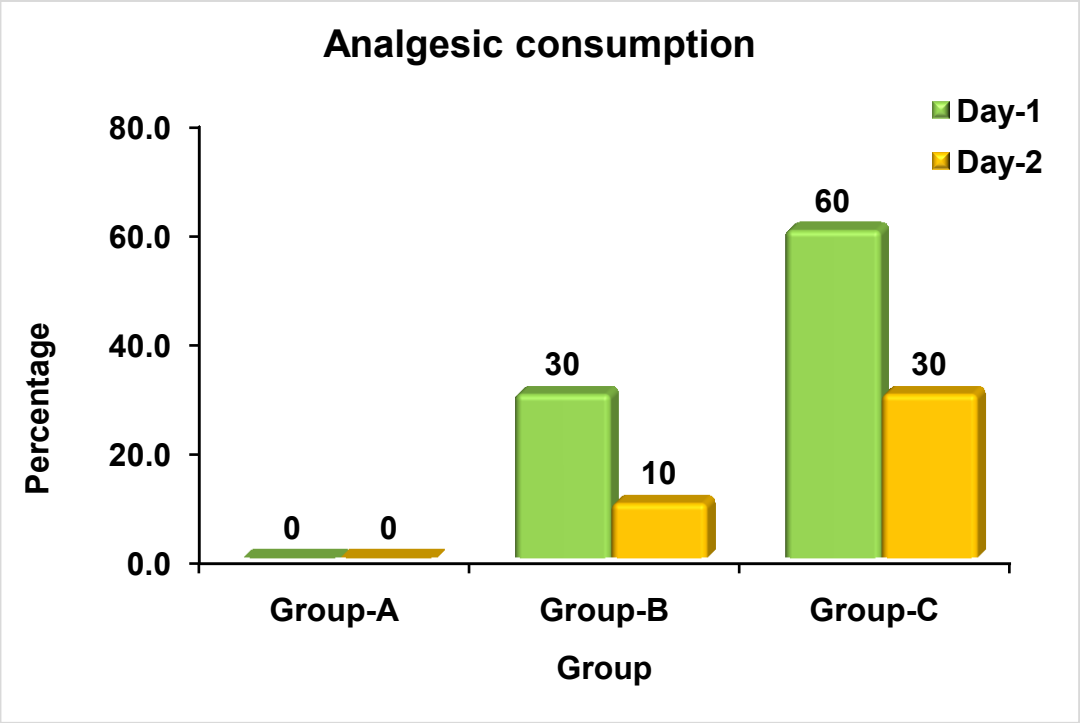
Graph 3 - Mean irregularity score of three archwires in non-extraction patients.



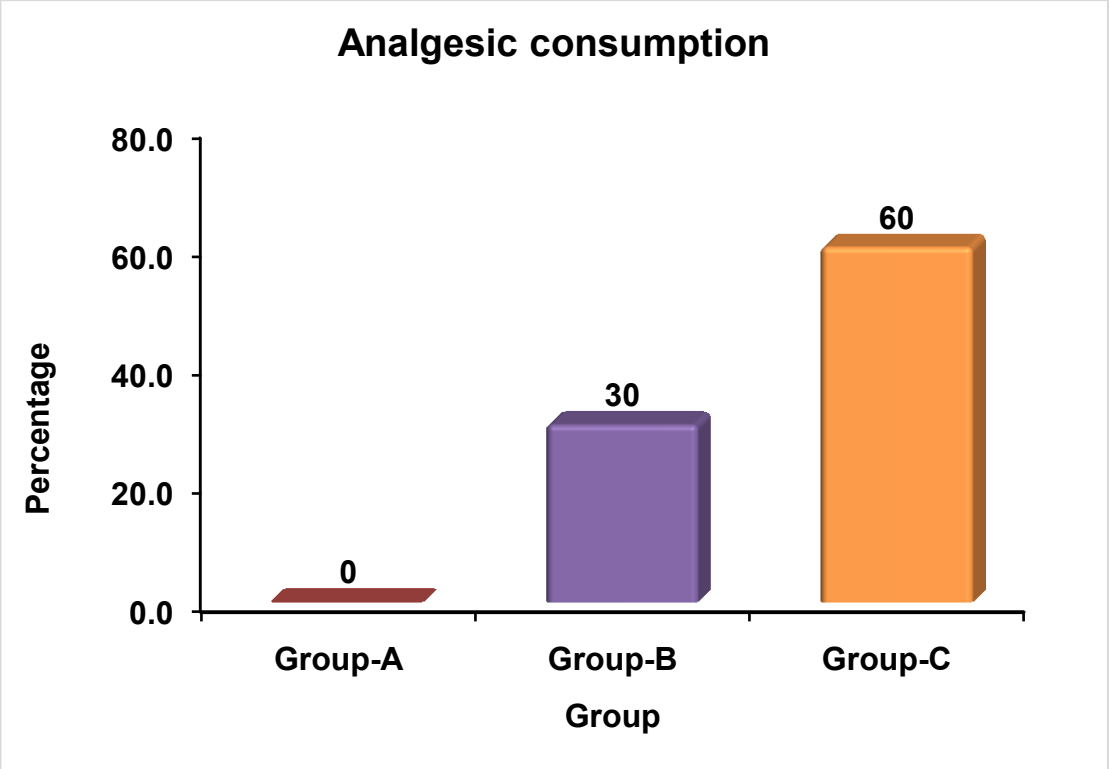
Graph 4 - Mean pain score of the three groups from day 1 to day 7



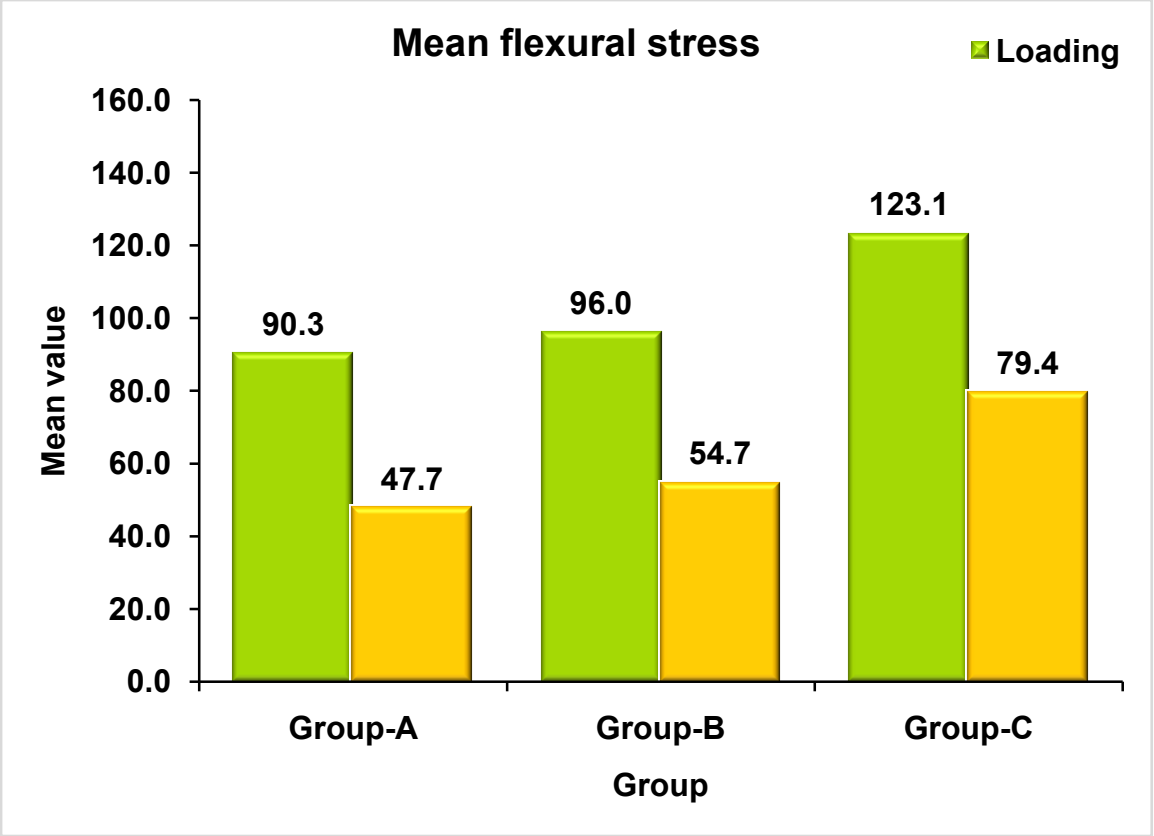
Graph 5 – Analgesic consumption on day 1 and day 2



Graph 6 - Overall analgesic consumption



Graph 7 – Mean loading and unloading flexural stress values of the archwires of the three groups



DISCUSSION

Lower anterior crowding is one the most common dental malocclusions observed. **Kharbanda**[44] et al did a study on 4500 school children aged between 5-13 years and concluded that crowding was a common trait and existed in 11.7% of the children population. A similar study by **Reddy**[45] et al on 2135 school children between 6-10 years showed that 11.8% of children had lower anterior crowding. Several etiological factors play an important role in mandibular crowding like genetics, gender, race, arch width, arch length, tooth size and shape. In genetics the malocclusion can be associated with any syndromes, supernumerary teeth, missing teeth, ectopic eruption etc. Non-genetic factors like arch length and tooth size discrepancy, trauma can result in mal-occlusion. Muscular factors like high frenal attachment, asymmetry due to facial muscle paralysis can also be a contributing factors to mal-occlusion.

During these orthodontic treatment procedures, pain is an inevitable factor that accompanies almost all the patients[13]. The most common cause for pain during the initial stages of orthodontic treatment is the excessive force delivered by the aligning archwires. Thus it has become a important aspect in selecting the proper archwires which will deliver the optimum force to the teeth thus reducing the chances of pain and improving the treatment efficiency.

Arch wires are the most important active component of the Orthodontic appliance which should deliver light continuous forces to bring about precise tooth movement. Aligning arch wires are used during the initial phase of treatment to correct crowding and rotation. Lower anteriors being the smallest teeth in the dentition with reduced root surface area need much low force for correction compared to posteriors. In case of severe crowding even more lower forces are required, as the tooth movement is much more and takes even more time. In periodontally compromised cases, even lesser forces are required as the area of periodontium available is also reduced. Incidentally, pain is experienced predominantly in the lower anteriors. An ideal wire to cater to this situation should be very flexible to cause less pain and should be cost effective and biocompatible [4](Kapila & Sachdeva1989).

The earliest arch wire introduced was gold. However it was not widely used because of its cost and its ability to fracture under stress. Stainless steel was introduced later in the 1930's as an alternative to gold[4]. In 1960's Elgiloy was introduced which had similar properties as that of stainless steel but delivered less force. Beta titanium alloy was introduced in the 1950's which was more flexible than Elgiloy.

Additional flexibility with low load deflection rate is an important mechanical property of initial arch wires[11]. This enables

the wire to engage the teeth in malalignment and allows unraveling with least pain and discomfort to the patient.

Nickel titanium alloys were introduced by William.F. Beuhler at Naval Ordinance Laboratory[6]. These nitinol wires had excellent elastic recovery property but they lacked superelasticty and shape memory because of the process of cold working of the alloy during manufacturing. Superelastic NiTi was later introduced as Chinese NiTi[7] and Japanese NiTi[8] which yielded better mechanical properties than Nitinol. According to Profitt, Bennett and McLaughlin, the first phase of treatment deals with alignment and correction of vertical and horizontal discrepancies by levelling out the arches, and the initial aligning wires should apply light continuous force.

In the recent years Forestadent introduced a new NiTi arch wire called Biostarter. The manufacturers claim that the these archwires are extremely flexible and expresses correct gentle force on the dentition. In addition, they claim that the uniquely smooth surface of Biostarter archwires reduces the friction between archwire and bracket by up to 30%. Due to the combination of the unique characteristics these intelligent wires from Forestadent® work more gently and efficiently. The orthodontic treatment will be completed faster.

However no published articles were available regarding the clinical test to evaluate the clinical efficiency of this wire.

Thus this study has been chosen to compare the clinical efficiency of this low friction biostarter NiTi archwire, a heat activated NiTi archwire and Superelastic NiTi archwire in unraveling the lower anterior crowding. In addition the pain perceived by the patients receiving these archwires and the stress exerted by these wires have also been compared.

LITTLE'S IRREGULARITY INDEX:

Lower anterior crowding can be measured by several quantitative methods. Most common method utilized for measurement of crowding is the Little's Irregularity Index (LII)[41]. Little described his Irregularity Index in 1975. In this measurement system, the linear displacement of the anatomic contact points is measured from the mesial of the left mandibular canine to the mesial of the right mandibular canine. The measurements are performed in millimeters. In total, five measurements are made and then added together. Perfect alignment would have a score of zero; the greater the irregularity or malalignment, the greater the score. The Irregularity Index represents the total distance that anatomic contact points would need to be moved in order to achieve ideal alignment

In clinical practice, the lower anterior region is one most common segment, where severe crowding presents[42]. This predisposes to reduced inter bracket span where archwire engagement is not easy except by very flexible wires. These initial Alignment Wires generate very low force in spite of maximum deflection and cause alignment with least pain. So in this study, the alignment efficiency of such initial alignment wires like 0.014 low friction Biostarter NiTi, 0.014 Heat activated NiTi and 0.014-Superelastic NiTi was compared in moderate to severe lower anterior crowding cases.

MEASUREMENT :

There are two methods of measurement of irregularities - direct and in direct methods. Direct methods involves the use of a vernier caliper whereas indirect method include the use of reflex microscope, coordinate measuring machine and CAD/CAM .

Zilberman[46] et al 2003 performed a study to test the accuracy of measuring casts with the aid of digital calipers or ortho CAD and they concluded that measurement with digital calipers on plaster models produce the most accurate and reproducible results . The ortho CAD measurement tool showed high accuracy and reproducibility but was inferior to measurement done on plaster models with digital calipers. In the present study however, direct measurements with digital caliper was used for measurement.

In the present study unraveling efficiency of the wire was seen for a span of 12 weeks with only a residual crowding not addressed by the initial wire which would require the next bigger size alignment wire to take over.

To compare mean values between groups one-way ANOVA is applied followed by Tukey's HSD post hoc tests for multiple pairwise comparisons. To compare mean values between time points repeated measures ANOVA using General Linear Models is applied.

OVERALL UNRAVELING EFFICIENCY OF THE THREE ARCHWIRES INCLUDING BOTH EXTRACTION AND NON-EXTRACTION PATIENTS

The mean and standard deviation pre-treatment values for Little's Index for Biostarter group, Heat activated NiTi group and superelastic NiTi group were 6.910±1.6079mm, 6.910±1.5502mm and 6.780±1.4703mm respectively and for 12^{th} week it was .000mm, .640±.8720mm and .910±.8319mm respectively. All the three wires have excellent unraveling efficiency.

In overall unraveling efficiency including both extraction and non-extraction cases, one way ANOVA showed that there is statistical significant difference in the Little's Index values between the three wires at 8^{th} and 12^{th} week.

At 8th week the mean values of biostarter low friction NiTi archwires (.400±.8894mm) shows **statistically significant** reduction in the crowding score when compared to Heat activated NiTi (2.180±.7983mm) and Superelastic NiTi (2.290±1.0093mm). **(P=0.96)**

At 12th week the mean values of biostarter NiTi archwires (.000mm) shows **statistically significant** reduction in the crowding score when compared to Superelastic NiTi (.910±.8319mm). **(P=0.018)**

On comparing the reduction in the mean irregularity scores of the three wires from T0 to T3 individually using General Linear Model (Repeated Measures ANOVA), all the three wires have performed efficiently in unraveling the crowding.

The Repeated measures ANOVA test using General Linear Models confirms that there is **no statistical significance** seen in the overall performance among the three archwire types in aligning the irregularity. **(P = 0.64)**

CláudiaMaria[18] et al compared the duration required for correction of mandibular anterior crowding using two arch wire sequences, one with conventional nickel-titanium (NiTi) arch wires and the other with conventional and NiTi heat-activated arch wires.

Twenty-two boys and girls (mean age: 16.68 ± 2.66) with moderate crowding (3–6mm) were assigned randomly to one of two groups and followed up for five months (six assessments) when arch wires were changed. At the end of follow-up, mandibular crowding was corrected in 100% of the cases in the group treated with NiTi heat-activated arch wires, whereas about 30% of those treated with conventional NiTi arch wires were not completely corrected. There was a significant difference in time to complete treatment between groups. The results of this study didn't relate to our study.

Nikolas Pandis[15] et al have compared the alignment efficiency of Copper-Nickel-Titanium and conventional Nickel Titanium arch wires. 30 patients were taken in each group and the mean Little's Index scores at To is 5.3 and 5.6 for CuNiTi and conventional NiTi respectively and the resulting standard deviation is 2.3 and 2.0 respectively. The author had concluded that there is no significant difference in the decrowding efficiency of CuNiTi and conventional NiTi and it is similar to our study.

Reem Sh.Abdel Rahman[3] et al have compared the alignment efficiency of 3 aligning arch wires namely, Conventional NiTi, Super Elastic NiTi and Thermoelastic NiTi initial arch wires. In this study 25 patients were taken in each group and the mean Little's Index scores at T0 was 5.96 for all the groups and during 8 weeks the reduction in the Little's Index scores were 1.23, 1.10 and 1.24

for Super elastic NiTi, Thermal NiTi and Conventional NiTi respectively. This study concluded that there was no significant differences in the alignment efficiency of Conventional NiTi which is similar to our study.

Since both the extraction and non-extraction cases have been included in this study, it has become a necessity to compare the efficiency of the three wires in both extraction cases and non-extraction cases separately.

UNRAVELING EFFICIENCY OF THE THREE ARCHWIRES IN EXTRACTION PATIENTS

The mean and standard deviation pre-treatment values for Little's Index for Biostarter group, Heat activated NiTi group and superelastic NiTi group were 7.200±1.5524mm, 7.500±1.5116mm and 7.420±1.5770mm respectively and for 12^{th} week it was .000mm, .760±1.0784mm and .800±.7714mm respectively. All the three wires have excellent unraveling efficiency.

The unraveling efficiency of the archwires among the extraction cases in the three groups using one way ANOVA showed that there is statistical significant difference in the Little's Index values between the three wires at 8^{th} week.

At 8th week the mean values of biostarter NiTi archwires (.400±.8894mm) shows **statistically significant** reduction in the crowding score when compared to Heat activated NiTi (2.180±.7983mm) and Superelastic NiTi (2.290±1.0093mm) archwires. **(P=0.014)**

On comparing the reduction in the mean irregularity scores of the three wires from T0 to T3 individually using General Linear Model (Repeated Measures ANOVA), all the three wires have performed efficiently in unraveling the crowding.

The Repeated measures ANOVA test using General Linear Models confirms that there is **no statistical significance** seen in the overall performance among the three archwire types in aligning the irregularity in extraction cases. **(P = 0.130)**

UNRAVELING EFFICIENCY OF THE THREE ARCHWIRES IN NON-EXTRACTION PATIENTS

The mean and standard deviation pre-treatment values for Little's Index for Biostarter group, Heat activated NiTi group and superelastic NiTi group were 6.620±1.7880mm, 6.320±1.5007mm and 6.140±1.1632mm respectively and for 12th week it was .000mm, .520±.7155mm and 1.020 ±..9654 mm respectively. All the three wires have excellent unraveling efficiency.

The unraveling efficiency of the archwires among the non-extraction cases in the three groups using one way ANOVA showed that there is statistical significant difference in the Little's Index values between the three wires at 8th week.

At 8th week the mean values of biostarter NiTi archwires (.520±1.1628mm) shows **statistically significant** reduction in the crowding score when compared to Heat activated NiTi(2.200± .8944mm) and Superelastic NiTi (4.300±.9138mm) archwires. **(P=0.014)**

On comparing the reduction in the mean irregularity scores of the three wires from T0 to T3 individually using General Linear Model (Repeated Measures ANOVA), all the three wires have performed efficiently in unraveling the crowding.

The Repeated measures ANOVA test using General Linear Models confirms that there is **no statistical significance** seen in the overall performance among the three archwire types in aligning the irregularity in non-extraction cases. **(P = 0.484)**

The above results shows that all the three aligning archwires performance are similar in both extraction and non-extraction cases.

PAIN PERCEPTION

This level of pain and discomfort is an important factor in discouraging patients from seeking orthodontic treatment. Ninety-one percent of orthodontic patients reported some degree of pain or discomfort at some stage during treatment.[13] Patients reported variable degrees of pain, with some patients reporting no pain at all. The majority of patients (95%) reported pain 24 hours following the insertion of a fixed orthodontic appliance.[47] The variations in individual responses to the orthodontic archwires have led several groups of investigators to look for factors that could be helpful in predicting which patients will experience the most pain. Discomfort may be influenced by various factors which includes the force generated by the archwire, the ligation method, soft tissue ulceration, or difficulties with mastication. Light and continuous forces are mandatory to achieve physiologic tooth movement. [1,2] It is a known fact that superelastic nickel-titanium (NiTi) archwires are capable of producing light continuous forces and are capable of achieving reliable tooth movement with minimal patient discomfort and tissue trauma.[48] Few studies evaluated the pain intensity experienced by patients during the initial alignment stage of treatment with different archwires.[23,25]As the manufacturer claim that biostarter archwire from forestadent company is extremely flexible and deliver less force to the teeth thereby reducing the pain/discomfort to the patients, this study has been undertaken to evaluate and compare the discomfort caused by Biostarter NiTi

archwire, Heat activated NiTi archwire and Nitiniol Superelastic NiTi archwire.

The Visual Analogue scale (VAS) has been used to quantify the pain experienced by the patients after the insertion of the archwire from day 1 to day 7. The recording sheet has been given to the patients with seven visual analogue scales and they were clearly explained about the method to complete the VAS recording sheet.

The mean pain score of patients who received biostarter archwire was the least when compared to the mean pain score of patients who received the other two archwires on all the days. And also no patient perceived pain on 7^{th} day irrespective of the archwire.

The mean pain score of the Biostarter archwire group were the least and the Nitinol superelastic group perceived the highest mean pain score with the heat activated NiTi group in between the two groups and each group significantly differed in mean pain score from other groups on all days except the seventh day.

This shows that patients who received the Biostarter NiTi archwire perceived the least pain. It has also been found that there was a significant amount of reduction in the mean pain score each day in all the three groups.

Thus it can be concluded that the biostarter archwire delievered less force when compared to the other two archwires resulting in least discomfort to the patients.

ANALGESIC CONSUMPTION

It is shown that no patients have consumed analgesic in Group-A, with the highest percentage of analgesic consumption in Group – C.

There is a statistical significance in the amount of analgesic consumption between Group-A and Group-C.

Patients consumed analgesic only for the first two days, thereafter no patient had taken analgesic in all the three groups.

Thus co-relating the pain perception and analgesic consumption in all the three groups, it has been concluded that the Biostarter archwire belonging to Group-A delivered less force to the teeth thus causing the least discomfort to the patients when compared to the other two archwires.

Reem Sh.Abdel Rahman[30] et al compared the intensity of pain perceived by the patients receiving three aligning archwires namely the 0.014 inch Superelastic NiTi, 0.014 inch Thermoelastic NiTi and 0.014 inch conventional NiTi. In this study 25 patients

were taken in each group. The highest mean pain score were 5.72, 6.32, 6.21 for Super elastic NiTi, Thermal NiTi and Conventional NiTi respectively. Thus the study concluded that there was no significant differences in the perception of pain among the three different aligning archwires. The result of this study does not relate to our study. A high percentage (67%) of patients relied on analgesics for symptomatic relief in this study. No significant difference was found in the amount of analgesic consumption between superelastic and conventional NiTi archwires. However, the need for analgesics was significantly different between superelastic and thermoelastic wire groups with the highest percentage of analgesic consumption in thermoelastic group. This again does not relate to our study since highest percentage of analgesic consumption is seen in superelastic NiTi group in our study.

Anand Ambekar[29] compared the amount of pain and discomfort experienced by the patients receiving the three aligning archwires namely 0.018 inch NiTi archwire, 0.018 inch copper NiTi archwire and 0.0175 multistranded stainless steel archwire. The mean pain score on the 10^{th} hour, 1^{st} day,2^{nd} day and 3^{rd} day reveals that mean pain score of copper NiTi group is significantly less when compared to superelastic NiTi group. Whereas in our study significantly least amount of pain is seen in the group with Biostarter lowfriction NiTi archwire when compared to heat activated NiTi and Superelastic NiTi.

FLEXURAL STRESS DISTRIBUTION IN THE ARCHWIRES

The ideal archwires are designed to move teeth with light and continuous forces. Such forces may reduce the potential for patient discomfort, tissue hyalinization, and undermining resorption[1,2]. When the force is applied, the archwire should behave elastically over a period of weeks to months. It has been accepted in orthodontics that light and continuous forces would be desirable for obtaining physiologic and controlled tooth movement.[1,2] For this purpose, the use of superelastic and heat-activated nickel-titanium archwire has been suggested.

The manufacturer of Biostarter archwire claims that their wire is extremely flexible and will exert less stress to the tooth and its supporting structures, thus resulting in a faster tooth movement. In order to evaluate this, the stress distributed in the three archwires after using in the patients dentition with moderate to severe crowding for a period of 12 weeks have been evaluated using three point bending test.

The mean loading flexural stress values are 90.3MPa, 96.0 MPa, 123.1 MPa for the Biostarter NiTi, Heat activated NiTi and Superelastic NiTi archwires respectively. The mean unloading flexural stress values are 47.7 MPa, 54.7 MPa, 79.4 MPa for the Biostarter, Heat activated NiTi and Superelastic NiTi archwires respectively. The results shows that the Bio-starter NiTi arch wire

exerted the least loading and unloading flexural stress among the three NiTi archwires but the mean stress value of Bio-starter NiTi archwire is not statistically significant between the three archwires. Thus Biostarter NiTi archwire is more flexible and exerts less flexural stress to the dentition when compared to the heat activated NiTi archwire and Superelastic NiTi archwire.

SUMMARY

Orthodontic wires generate biomechanical forces which are transferred to the teeth through brackets, for tooth movement. A well planned Orthodontic treatment starts with very flexible wires fully engaged into the brackets. Dental crowding is one of the most commonly occurring malocclusions and initial aligning and levelling involves unraveling of crowding. Nickel-Titanium wires have low modulus of elasticity, low stiffness, long range of action, shape memory and super elasticity and hence the most preferred initial arch wire.

In order to evaluate clinically the unraveling efficiency of the three initial aligning archwires in mandibular anterior crowding, pain perceived by the patients and the flexural flexural stress distributed in these three archwires wires namely, 0.014" Forestadent Biostarter NiTi, 0.014" 3M Heat activated NiTi and 0.014" 3M Superelastic NiTi, this prospective double blinded clinical trial was conducted.

All the patients were informed about the treatment protocol and were strapped up with 0.22 MBT prescription stainless steel metal brackets and the wires placed in the lower arch and ligated with elastomeric ligatures. The patients were reviewed every 4 week and the wire was reactivated until 12th week of the treatment. Occlusal photographs and study models to measure the unraveling potential using digital vernier caliper were taken at each appointment.

The pain perceived by the patients for the first seven days after the placement of the initial NiTi wires were recorded by the patients using Visual Analogue Scale and analysed.

At the end of 12 weeks these wires were removed from the patient mouth and the flexural stress distributed in these wires were measured using three point bending test with Instron 8874 machine.

CONCLUSION

The present study revealed that the average amount of unraveling done by Biostarter NiTi, Heat activated NiTi, Superelastic NiTi were 2.66 mm, 3.5 mm and 3.58 mm respectively. As the observed P value is **0.064** (>0.05), repeated measures ANOVA using General Linear Model showed that comparison of the three archwires were found to be **statistically not significant.**

This study also revealed that the average amount of pain perceived by patients receiving Biostarter NiTi, Heat activated and Superelastic NiTi were 1.6, 3.8 and 4.9 respectively . There is a significant difference in the mean pain score among the three groups every day**(P=0.00)**. The mean pain scores between the three groups confirms that the Biostarter NiTi caused least discomfort to the patients followed by Heat activated NiTi and Superelastic NiTi.

The mean loading and unloading flexural stress distributed in Biostarter NiTi was 90.3 MPa and 47.7 MPa respectively, while amount of mean loading and unloading flexural stress distributed in Heat activated was 96.0 MPa and 54.7 MPa respectively and in Superelastic NiTi it is as 123.1 MPa and 79.4 MPa respectively . As the observed P value between the three wires were **0.107**(>0.05) for loading flexural stress and **0.070**(>0.05) for unloading flexural stress, Kruskal Wallis test showed that comparison of the flexural stress distributed in three different arch were found to be **statistically not significant**. But the mean unloading flexural stress

of Biostarter NiTi archwire is the least among the three wires thus exerting the least flexural stress to the teeth, which has resulted in least discomfort to the patients.

There is no statistically significant difference in the unraveling efficiency between 0.014" Biostarter NiTi, 0.014" Heat activated NiTi and 0.014" Superelastic NiTi. But the patients receiving the Biostarter NiTi experienced the least pain/discomfort and also the flexural stress distributed in this archwire was the least among the three archwires, even though not statistically significant.

This study opened an avenue to do further research on stress distribution, surface changes and the internal architecture of various archwires before and after the alignment phase of orthodontic treatment with large sample size using different mechanics.

BIBLIOGRAPHY

1. **Burstone CJ**. Variable-modulus orthodontics. Am J Orthod Dentofac Orthop 1981Jul;80(1):1–16.
2. **Linge L, Linge BO.** Patient characteristics and treatment variables associated with apical root resorption during orthodontic treatment. Am J Orthod Dentofacial Orthop.1991Jan;99(1):35–43.
3. **Abdelrahman RSh, Al-Nimri KS, Al Maaitah EF.** A clinical comparison of three aligning archwires in terms of alignment efficiency: A prospective clinical trial. Angle Orthod. 2015May;85(3):434 – 439.
4. **Kapila S, Sachdeva R.** Mechanical properties and clinical applications of orthodontic wires. Am J Orthod Dentofac Orthop. 1989Aug;96(2):100–109
5. **O'Brien K, Lewis D,Shaw W, and Combe E.** A clinical trial of aligning archwires. Eur J Orthod. 1990Nov;12(4):380-384.
6. **Thompson SA.** An overview of nickel–titanium alloys used in dentistry. Int Endod J. 2000Jul;33(4):297-310.
7. **Burstone CJ, Qin B, Morton JY.** Chinese NiTi wire: a new orthodontic alloy. Am J Orthod. 1985Jun;87(6):445–452.
8. **Miura F, Mogi M, Ohura Y, Hamanaka H.** The super-elastic property of the Japanese NiTi alloy wire for use in orthodontics. Am J Orthod Dentofacial Orthop. 1986Jul;90(1):1–10.
9. **Buehler WJ, Gilfrich JV, Wiley RC**. Effect of low-temperature phase changes on the mechanical properties of

alloys near composition NiTi. J Appl Phys 1963Jun;34(5):1475-1477.

10. **Sachdeva R.** Sure-smile: technology-driven solution for orthodontics. Tex Dent J 2002Jul;119(7):608-615.
11. **Brantley WA, Webb CS, Soto U, et al**. X-ray diffraction analyses of copper Ni–Ti orthodontic wires. J Dent Res. 1997;76:401.
12. **Pillai AR, Gangadharan A, Kumar S, Shah A.** Comparison of the frictional resistance between archwire and different bracket system: An in vitro study. J Pharm Bioallied Sci. 2014Jul;6(1):S150-5.
13. **Lew KK.** Attitudes and perceptions of adults towards orthodontic treatment in an Asian community. Community Dent Oral Epidemiol. 1993Feb;21(1):31–35.
14. **Cobb N.W. 3rd, Kula .KS, C. Phillips C, Proffit WR.** Efficiency of multistrand steel, superelastic Ni-Ti and ion implanted Ni-Ti arch wires for initial alignment. Clin Orthod Res , 1998 Aug;1(1): 12-19.
15. **Pandis N, Polychronopoulou A, Eliades T.** Alleviation of mandibular anterior crowding with copper-nickel-titanium vs nickel-titanium wires: A double-blind randomized control trial Am J Orthod Dentofacial Orthop. 2009 Aug: 136(2):152.e1-7.
16. **Ong E, Ho C, Miles P.** Alignment efficiency and discomfort of three orthodontic archwire sequences:a randomized clinical trial. J Orthod.2011 Mar;38(1):32-9

17. **Sandhu SS, Shetty VS, Mogra S, Varghese J, Sandhu J, Sandhu JS**. Efficiency, behavior, and clinical properties of superelastic NiTi versus multistranded stainless steel wires-.A prospective clinical trial. Angle Orthod.2012 Sep;82(5):915-21.

18. **Serafim CM, Gurgel Jde A, Tiago CM, Tavarez RR, Maia Filho EM**. Clinical Efficiency of Two Sequences of Orthodontic Wires to Correct Crowding of the Lower Anterior Teeth. ScientificWorldJournal 2015 Jun;690280

19. **Fırat G, Kutalmıs B, Serkan O, Atakan B.** Comparison of arch width and depth changes and pain/discomfort with conventional and copper Ni-Ti archwires for mandibular arch alignment. Journal of the World Federation of Orthodontists. 2018:24-28

20. **Aydın B, Şenışık NE, Koşkan Ö.** Evaluation of the alignment efficiency of nickeltitanium and copper-nickel-titanium archwires in patients undergoing orthodontic treatment over a 12-week period: A single-center, randomized controlled clinical trial. Korean J Orthod.2018 May;48(3):153-162.

21. **Mahmoudzadeh M, Farhadian M, Alijani S, Azizi F.** Clinical comparison of two initial arch wires (A-NiTi and Heat Activated NiTi) for amount of tooth alignment and perception of pain: A randomized clinical trial. Int Orthod.2018Mar ;16(1):60-72.

22. **Ngan P, Kess B, Wilson S**. Perception of discomfort by patients undergoing orthodontic treatment .Am J Orthod Dentofacial Orthop.1989 Jul;96(1):47-53.

23. **Jones M, Chan C**. The pain and discomfort experienced during orthodontic treatment: a randomized controlled clinical trial of two initial aligning archwires. Am J Orthod Dentofacial Orthop.1992Oct;102(4):373-81.

24. **Scheurer PA, Firestone AR, Burgin WB.** Perception of pain as a result of orthodontic treatment with fixed appliances.Eur J Orthod.1996 Aug

25. **Fernandes LM, gaard B, Skoglund L**. Pain and discomfort experienced after placement of a conventional or a superelastic NiTi aligning archwire: A randomized clinical trial. Journal of Orofacial Orthopedics 1998 Nov;59(6):331–9.

26. **Ertan Erdinc AM.** Perception of pain during orthodontic treatment with fixed appliances. The European Journal of Orthodontics. 2004 Feb 1;26(1):79–85.

27. **Sandhu SS, Sandhu J**. A randomized clinical trial investigating pain associated with superelastic nickel–titanium and multistranded stainless steel archwires during the initial leveling and aligning phase of orthodontic treatment. Journal of Orthodontics. 2013 Dec;40(4):276–85.

28. **Campos MJ da S, Fraga MR, Raposo NRB, Ferreira AP, Vitral RWF**. Assessment of pain experience in adults and children after bracket bonding and initial archwire insertion. Dental Press Journal of Orthodontics. 2013 Oct;18(5):32–7

29. **Ambekar DA.** Pain and Discomfort Associated With Initial Alignment with Three Different Archwires-A Clinical Study.

IOSR Journal of Dental and Medical Sciences. 2014;13(2):47–50

30. **Abdelrahman RS, Al-Nimri KS, Al Maaitah EF**. Pain experience during initial alignment with three types of nickel-titanium archwires: A prospective clinical trial. Angle Orthod. 2015 Nov;85(6):1021–6.
31. **Johal A, Ashari AB, Alamiri N, Fleming PS, Qureshi U, Cox S, et al**. Pain experience in adults undergoing treatment: A longitudinal evaluation. Angle Orthod. 2018 May;88(3):292–8.
32. **Gurgel J de A, Kerr S, Powers JM, LeCrone V**. Force-deflection properties of superelastic nickel-titanium archwires. Am J Orthod Dentofacial Orthop. 2001 Oct;120(4):378–82.
33. **Wilkinson PD, Dysart PS, Hood JAA, Herbison GP**. Load-deflection characteristics of superelastic nickel-titanium orthodontic wires. Am J Orthod Dentofacial Orthop. 2002 May;121(5):483–95.
34. **Parvizi F.** The load/deflection characteristics of thermally activated orthodontic archwires. The European Journal of Orthodontics. 2003 Aug 1;25(4):417–21.
35. **Gatto E, Matarese G, Di Bella G, Nucera R, Borsellino C, Cordasco G.** Load-deflection characteristics of superelastic and thermal nickel-titanium wires. The European Journal of Orthodontics. 2013 Feb 1;35(1):115–23.
36. **Lombardo L, Marafioti M, Stefanoni F, Mollica F, Siciliani G**. Load deflection characteristics and force level of nickel

titanium initial archwires. Angle Orthod. 2012 May;82(3):507–21.

37. **Fernandes DJ, Elias CN, Vidal R, Mendes A de M**. Mechanical Performance of Nickel-titanium Archwires. Materials Research. 2015 Nov 3;18(6):1264–77.
38. **Dechkunakorn S, Isarapatanapong R, Anuwongnukroh N, Chiranavanit N, Kajorchaiyakul J, Khantachawana** A. Mechanical Properties of Several NiTi Alloy Wires in Three-Point Bending Tests. Applied Mechanics and Materials. 2011 Aug;87:14–9.
39. **Rock WP, Wilson HJ**. Forces Exerted by Orthodontic Aligning Archwires. British Journal of Orthodontics. 1988 Nov;15(4):255–9.
40. **Phukaoluan A, Dechkunakorn S, Anuwongnukroh N, Khantachawana A, Kaewtatip P, Kajornchaiyakul J, et al.** Loading and Unloading Forces Following Addition of 5% Cu in Nickel-Titanium Alloy Used for Orthodontics. Key Engineering Materials. 2017 Feb;730:161–6.
41. **Little RM.** The irregularity index: a quantitative score of mandibular anterior alignment. Am J Orthod. 1975 Nov; 68(5):554-63
42. **Sebastian B.** Alignment efficiency of superelastic coaxial nickel-titanium vs superelastic single-stranded nickel-titanium in relieving mandibular anterior crowding: A randomized controlled prospective study. Angle Orthod. 2012 Jul;82(4):703–8.c

43. **Al-Khatieeb MM**. Influence of different recycling protocols on load deflection of nickel titanium orthodontic wire -An in vitro study. Am J Orthod Dentofacial Orthop 2008;120(6):654-63.

44. **Kharbanda OP. Sidhu SS**. Prevalence studies on malocclusion in India retrospect and prospect. J ind OrthodSoc 1993;24(4):115-18.

45. **Reddy, M Manjula.** Prevalence of Malocclusion among 6 to 10 Year old Nalgonda School Children; J Int Oral Health. Dec 2013; 5(6): 49.

46. **Zilberman O, Huggare JA, Parikakis KA.** Evaluation of validity of tooth size and arch width measurements using conventional and three dimensional virtual orthodontic models. Angle Orthod.2003 Jun;73(3):301-6.

47. **Jones M, Richmond S**. Initial tooth movement: force application and pain—a relationship? Am J Orthod. 1985; 88:111–116.

48. **Storey E, Smith R**. Force in orthodontics and its relation to tooth movement. Aust J Dent. 1952;56:11–18.

ANNEXURE

ANNEXURE I

INSTITUTIONAL ETHICAL COMMITTEE
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KUNDRATHUR, CHENNAI – 600072
Telephone no: 044-24780736, Email ID: madhadentalcollege@gmail.com
Affiliated to The Tamil Nadu Dr. M.G.R Medical University
DCI Recognition No: Lr.No.F.No. V.12017/75/2006-DE Dated: 01.11.2011

Ref. No :MDCH/MDS/EC/019 Date: 26.04.2017

Title of the work: Comparison of three aligning archwires in terms of alignment efficiency, stress distribution and pain perception. – A prospective clinical trial

Principal Investigator : Dr. Aboobacker Ali A
I year MDS

Department: Orthodontics and Dentofacial Orthopedics

The request for approval from the Institutional Ethical Committee (IEC) considered at the Institutional Ethics Committee meeting held on the 26-04-2017 at Madha Dental College and the documents related to the study referred above were discussed and reported to us through your letter have been reviewed. The decision of the members of the committee, the secretary and the Chairperson IEC of Madha Dental College is here under:

" Adviced to proceed with the study "

The members of the Committee, the secretary and the Chairman are pleased to approve the proposed work mentioned above, submitted by the Principal Investigator.

The principal investigators and their team are advised to adhere to the guidelines given below:

1. You should get detailed informed consent from the patients/participants and maintain confidentiality.
2. You should carry out the work without affecting regular work and without extra expenditure to the institution or the government.
3. You should inform the IEC in case of any change of study procedure, site and investigating guide.
4. You should not deviate from the area of work for which you have applied for ethical clearance.
5. You should inform the IEC immediately in case of any adverse events or serious adverse reactions. You should abide to the rules and regulations of the institution(s).
6. You should complete the work within the specific period and if any extension of time is required, you should apply for permission again to do the work.
7. You should submit the summary of the work to the ethical committee every 3 months and on completion of the work.
8. You should not claim any kind of funds from the institution for doing the work or on completion/ or for any kind of compensations.
9. The members of the IEC have the right to monitor the work without prior intimation.
10. Your work should be carried out under the direct supervision of the guide/Professor.
11. The investigator and guide should each declared that no plagiarism is involved, in this whole study and enclose the undertaking in dissertation/ thesis.

Secretary
Prof. Dr. M.C. Sainath. MDS
Principal-Madha Dental college and Hospital

PRINCIPAL
MADHA DENTAL COLLEGE & HOSPITAL
Kundrathur, Chennai 600 069.

Chairman
Prof. Dr. Gajendran, M.D
Dean-Madha Medical college and Hospital

DEAN
MADHA MEDICAL COLLEGE & R

ANNEXURE II

MADHA DENTAL COLLEGE AND HOSPITAL

DEPARTMENT OF ORTHODONTICS AND DENTOFACIAL ORTHOPEDICS

INFORMATION SHEET

We, From the Department of Orthodontics and Dentofacial Orthopedics, Madha Dental College and Hospital, Kundrathur,Chennai, are conducting a study **COMPARISON OF THREE ALIGNING ARCHWIRES IN TERMS OF ALIGNMENT EFFICIENCY, STRESS DISTRIBUTION AND PAIN PERCEPTION – A PROSPECTIVE CLINICAL TRIAL.**

The privacy of the subjects in the research will be maintained throughout the study. In the event of publication or presentation resulting from the research, no personally identifiable information will be shared.

- Taking part in this study is voluntary. You are free to decide whether to participate in this study or to withdraw at any time; your decision will not result in any loss of benefits to which you are otherwise entitled.
- The result of this special study may be intimated to you at the end of the study period or during the study if anything is found abnormal which may aid in the management or treatment.

Date:

Signature of Investigator Signature of Patient

தகவல் அறிக்கை படிவம்

- நாங்கள் மாதா பல் மருத்துவக்கல்லூரி மற்றும் மருத்துவமனையில் பல் மற்றும் தாடை சீரமைப்பு துரை பிரிவில் ஆய்வு நடத்துகின்றோம். அதற்காக நோயாளிகளை தேர்வு செய்கின்றோம்.
- இந்த ஆராய்ச்சியில் பங்கேற்கும் நோயாளியின் விபரங்கள் ஆய்வு முடியும் வரை இரகசியமாகவைக்கப்படும். ஆராய்ச்சியின் முடிவு பற்றிய பதிப்புகள் அல்லது வெளியீடுகள் யாருடைய தனிப்பட்ட விபரங்களும் பகிர்ந்து கொள்ளப்படமாட்டாது.
- இந்த ஆராய்ச்சியில் பங்கேற்கும் உங்கள் முடிவுதன்னிச்சையானது. இந்த ஆராய்ச்சியில் பங்கேற்கும் உங்களுக்கு எந்த நேரத்திலும் விலகிக்கோள்வதற்கு வாய்ப்புஉள்ளது. உங்களின் இந்த தீர்மானத்தினால் உங்களுக்கு இம்மருத்துவமனையில் வழங்கப்படும் பயன்களில் எந்த விதமாற்றமும் இருக்காது.
- இந்த சிறப்பு ஆய்வின்முடிவுகள், இந்த ஆய்வின் முடிவில் அல்லது ஆய்வின் போது ஏற்படும் எதிர்மறையான விளைவுகளை அந்நோயாளியின் நலன்கருதியோ அல்லது சிகிச்சை அளிக்கும் பொருட்டோ தெரிவிக்கப்படும்.

தேதி:

மருத்துவரின்கையொப்பம்

நோயாளின்கையொப்பம்

ANNEXURE III

MADHA DENTAL COLLEGE AND HOSPITAL

DEPARTMENT OF ORTHODONTICS & DENTOFACIAL ORTHOPEDICS

INFORMED CONSENT FORM

COMPARISON OF THREE ALIGNING ARCHWIRES IN TERMS OF ALIGNMENT EFFICIENCY, STRESS DISTRIBUTION AND PAIN PERCEPTION – A PROSPECTIVE CLINICAL TRIAL.

Patient Name:
Age/Sex:
Participant OP No:

"I have read the informed consent information, or it has been read to me in my own language by the investigator. I have had the opportunity to ask questions about it and any questions that I have asked have been answered to my satisfaction. I consent voluntarily to participate as a participant in this study, to disclose my personal information, photos for publication purpose and I understand that I have the right to withdraw from the study at any time without any way affecting my further medicalcare."

Date :

Signature/thumb impression of the patient :

Signature of the investigator :

மாதா பல் மருத்துவகல்லூரி மற்றும் மருத்துவமனை

பல் மற்றும் தாடை சீரமைப்பு துரை

நோயாளியின் பெயர் :

வயது\பாலினம்:

புறநோயாளி எண்:

நான் இந்த ஆய்வின் தகவல் அறிக்கையைபடித்தேன் ,அல்லது எனக்கு என்சொந்த மொழியில் வாசிக்கப்பட்டது. இந்த ஆய்வு பற்றிய கேள்விகளை கேட்க எனக்கு வாய்ப்பு அளிக்கப்பட்டது. மற்றும் என் கேள்விகளுக்கு திருப்தியான பதிலும் வழங்கப்பட்டது. நான் இந்த ஆய்வில் என் சொந்த விருப்பத்துடன் பங்கெற்கிறேன் மற்றும் யாரும் என்னை கட்டாயப்படுத்தவில்லை. மேலும் என் தகவல்கள் மற்றும் என் புகைப்படங்கள் இந்த ஆய்விற்காக பயன்ப்படுத்தலாம் என்று நான் என் முழுமனதோடு ஒப்புக்கொள்கிறேன். நான் இநத ஆய்வில் இருந்து எப்பொழுது வேண்டுமானாலும் விலகிக்கொள்ளலாம் என்பதை நான் அறிவென்.

தேதி:

நோயாளின்கையொப்பம்:

மருத்துவரின்கையொப்பம்:

ANNEXURE IV

PROFORMA

MADHA DENTAL COLLEGE AND HOSPITAL

DEPARTMENT OF ORTHODONTICS AND DENTOFACIAL ORTHOPEDICS

Name : Date:

O.P.D No : Age/Sex :

Postal address and contact number:

Chief Complaint :

Past medical history:

Past dental history :

History of previous orthodontic treatment:

Clinical Examination :

No. of Permanent teeth:

No. of deciduous teeth:

Unerupted teeth:

Arch alignment:

(i) Crowding:

(ii) Spacing:

(iii) Rotations:

Little's irregularity index :

(i) Pre –op:

(ii) 4th week:

(iii) 8th week:

(iv) 12th week:

Mechanotherapy used :

Straight wire appliance/ Begg's appliance/ Roth Pre-adjusted edgewise appliance/ MBT Pre-adjusted edgewise appliance

Treatment Modality: Extraction/ Non-Extraction

ANNEXURE V

VISUAL ANALOGUE SCALE

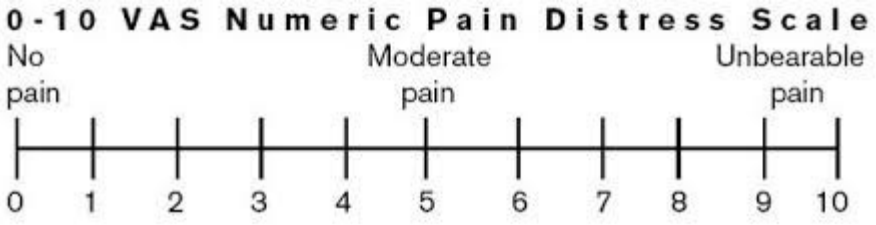
Patient Name:

Age :

Sex :

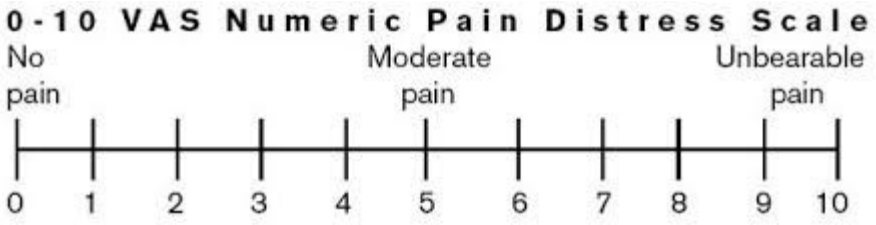
Day 1 Time of Recording :

Analgesics if taken, mention the time and the drug with dosage :



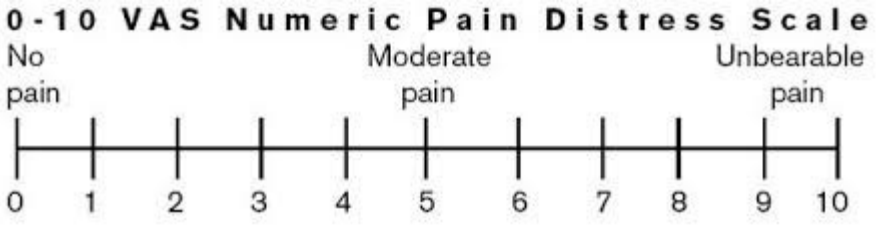
Day 2 Time of Recording :

Analgesics if taken, mention the time and the drug with dosage :



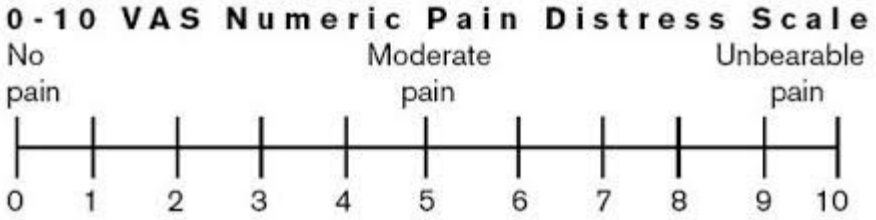
Day 3 Time of Recording :

Analgesics if taken, mention the time and the drug with dosage :



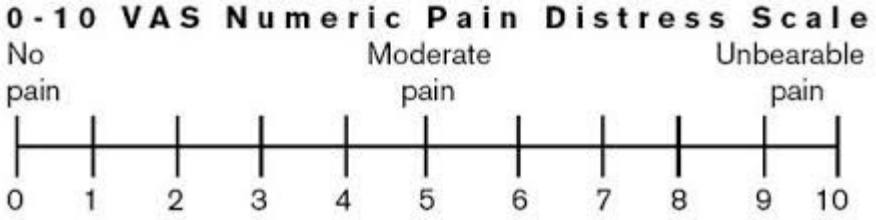
Day 4 Time of Recording :

Analgesics if taken, mention the time and the drug with dosage :



Day 5 Time of Recording :

Analgesics if taken, mention the time and the drug with dosage :



Day 6 Time of Recording :

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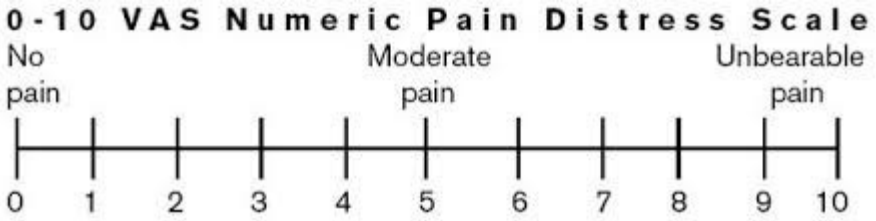
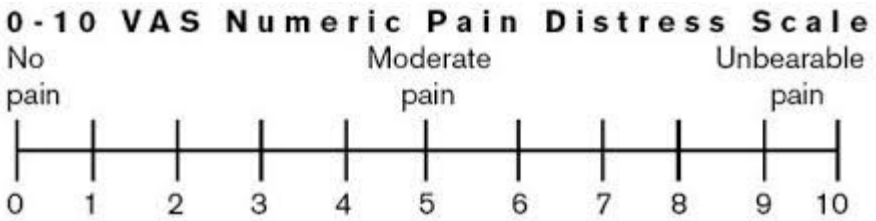


Day 7 Time of Recording :

Analgesics if taken, mention the time and the drug with dosage :



ANNEXURE VI

THREE POINT BENDING TEST CERTIFICATE

सिपेट : स्कूल फॉर अड्वान्स्ड रिसर्च इन पॉलिमर्स (एस ए आर पी) - ए आर एस टी पी एस
रसायन एवं पेट्रोरसायन विभाग
रसायन एवं उर्वरक मंत्रालय, भारत सरकार
टी वी के इंडस्ट्रियल एस्टेट, गिण्डी, चेन्नै – 600 032
फोन : +91-44-22254794
ई-मेल : arstps@cipet.gov.in / arstpscipet@gmail.com
वेब्साइट : www.cipet.gov.in / www.arstps.gov.in
मुख्यालय : सिपेट, गिण्डी, चेन्नै – 600 032.

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एक कदम स्वच्छता की ओर

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Department of Chemicals & Petrochemicals,
Ministry of Chemicals & Fertilizers, Govt. of India
T.V.K. Industrial Estate, Guindy, Chennai - 600 032.
Phone : +91-44-2225 4794
e-Mail : arstps@cipet.gov.in / arstpscipet@gmail.com
Website : www.cipet.gov.in / www.arstps.gov.in
Head office : CIPET, Guindy, Chennai - 600 032

04.12.2018

TO WHOM IT MAY CONCERN

This is to certify that **Dr. A. Aboobacker Ali**, Post graduate student from the Department of Orthothodontics and Dentofacial Orthopedics, Madha Dental College & Hospital, Kundrathur, Chennai has carried out Three Point Bending test in INSTRON 8874 machine was done at the division of CIPET: SARP-ARSTPS (R&D), Chennai for him thesis entitled **"Comparison of three aligning arch wires in terms of alignment efficiency, Pain perception and Stress distribution – A Prospective Clinical trial".**

This is for your information

Thanking you

With regards

Nalini R
Scientist

CIPET - SARP - ARSTPS * गिण्डी GUINDY * CHENNAI - 600 032.

ANNEXURE VII

URKUND

Urkund Analysis Result

Analysed Document: Thesis final.pdf (D47587790)
Submitted: 2/4/2019 8:32:00 PM
Submitted By: aboo91_dr@yahoo.com
Significance: 4 %

Sources included in the report:

harish thesis.docx (D35366526)
URKUND PLIAGIARISM WORD.docx (D34659307)
https://www.ncbi.nlm.nih.gov/pubmed/25090135
https://www.science.gov/topicpages/n/nickel-titanium+orthodontic+wires
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5932317/

Instances where selected sources appear:

11